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UNRESTRICTED

**Strategic Development of Renewable Energy Technology in  
Europe**

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A Thesis Submitted to the  
Energy and Environment Research Unit  
Faculty of Technology  
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for the degree of Doctor of Philosophy

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## **ABSTRACT**

This thesis addresses the development of industries manufacturing in the renewable energy sector. As the most mature of the renewable energy technologies, it specifically assesses the development of the wind turbine manufacturing industry up to the present in order to address what lessons may be learned for the future development of the industry and for other renewable energy industries. Data is presented in the form of a number of case studies which detail the comparative successes of Denmark, Germany, Spain and the UK in encouraging the growth of wind turbine industries.

Three areas of study are identified, and the data collected in the case studies applied to each. Firstly, the question of whether it is still possible for countries to stimulate national industries to successfully gain entry to the wind turbine manufacturing industry. Applying the historical data in the context of a typological theory on entrepreneurial success with regard to industrial phase, it is argued that such entry is still possible.

The remaining two areas of study are linked in that they both address what lessons might be learned from the international development of the wind turbine manufacturing industry in order for the UK to replicate the success of other nations. The first of these areas specifically addresses how lessons from elsewhere might enable UK access to the wind turbine manufacturing industry. The second area addresses the extent to which experiences in the wind turbine industry might provide lessons for entrants to the industries of newer, less mature renewable energy technologies.

In all areas, specific consideration is given to the use of 'regulatory subsidisation' of national industries by national governments, in order to create domestic competitive advantage.



<b>Contents</b>	<b>Page</b>
Publications	I
Acknowledgements	II
List of Tables	III
List of Figures	IV
Acronyms and Abbreviations	V
 Chapter 1: Introduction	 1
1.1 The Research Aims	1
1.2 Renewable Energy Technology Manufacturing and the UK	2
1.3 Introduction of Issues and Definition of Terms Relevant to this Research	3
1.3.1 Renewable Energy	4
1.3.2 Reasons for Implementing Renewable Energy	5
1.3.3 Social and Economic Motivations for Renewable Energy	7
1.3.4 Renewable Energy Manufacturing Industry	11
1.3.5 Wind Energy Industry	13
1.3.6 Wave and Tidal Stream Energy	13
1.3.7 Photovoltaic Energy	14
1.3.8 Barriers to Renewable Energy	15
1.3.9 National Innovation Strategy	18
1.3.9.1 The Impacts of the Social Sub-System	23
1.3.10 The Nature of Companies Involved in Renewable Energy Technology	24
1.4 Conclusion	26
Main Points of Chapter One	27
 Chapter 2: Methodology	 28
2.1 Research Aims	28
2.2 The Choice of the UK as the Focus for Study	29

2.3 The State of the Wind Industry	30
2.4 Methodology	33
2.5 Practical Aspects of the Research	35
2.6 Interviews	36
2.7 Problems	37
Main Points of Chapter Two	39
Chapter 3: Development and Protection of Industry	40
3.1 Introduction	40
3.2 Support vs. Protection	43
3.3 The Role of Regulation in Innovation Policy	44
3.4 Options for Developing and Protecting Industry	49
3.4.1 Research and Development	49
3.4.2 Education	51
3.4.3 Protectionism	53
3.5 Pitfalls of Protectionism	54
3.6 Regulatory Protectionism	57
3.7 Financial Trade Barriers	61
3.7.1 Subsidy	61
3.7.2 Tariffs and Quotas	65
3.7.3 Dumping	65
3.8 Non-tariff Barriers	66
3.9 International Agreements Regarding Protectionism	68
3.10 Protectionism and the European Union	72
3.11 Application of Protectionist Methods	73

Main Points of Chapter Three	73
Chapter 4: The Development of the Danish Wind Turbine Industry	74
4.1 Introduction	74
4.2 Historical Use of Wind Energy in Denmark	74
4.3 The Risø Test Station	84
4.4 The Role of Co-operatives	86
4.5 Danish Turbines and the Learning Process	89
4.6 The Californian Market	92
4.7 Planning Issues	98
4.8 Development of the Industry during the 1990's	100
4.9 The Siting of Manufacturing Facilities	101
4.10 Innovation in the Danish Turbine Manufacturing Industry	103
4.11 The Renewable Portfolio Standard	104
4.12 The Development of the Danish Turbine Manufacturing Industry in the Context of the Danish National Innovation System	109
4.13 Protectionism in the Danish Turbine Manufacturing Industry	116
4.14 Offshore Wind	122
4.15 The Behaviour of the Danish Turbine Industry in the World Marketplace	125
4.16 Summary	126
4.17 Discussion	129
4.17.1 The Reproducibility of Danish Wind Energy Policy	129
Main Points of Chapter Four	140
Chapter 5: The Development of the German Wind Turbine Industry	141
5.1 Introduction	141

5.2 A Brief History of Wind Energy in Germany	142
5.3 Renewable Energy and the German Electricity Supply Industry	146
5.4 The German Electricity Sector	147
5.5 The Electricity Feed-In Law	150
5.6 Other sources of Funding for German Wind Energy	160
5.7 The Role of the German Regions	164
5.8 Planning Issues	166
5.9 The German Wind Turbine Manufacturing Industry	167
5.10 The Development of the German Wind Turbine Industry in the Context of the German National Innovation System	170
5.11 Effects of the Federal Nature of Germany	179
5.12 The German Domestic Market	180
5.13 The Future of the German Wind Turbine Industry	182
5.14 The Reproducibility of German Policy	184
5.15 Discussion	189
Main Points in Chapter Five	190
Chapter 6: The Development of the Spanish Wind Turbine Industry	191
6.1 The Growth of Wind Energy Usage in Spain	191
6.2 Spanish Wind Energy Policy	193
6.3 The Role of Regional and Local Government in Spanish Wind Energy	198
6.4 The Potential for Protectionism in Spanish Policy	204
6.5 The Growth of a Spanish Wind Turbine Industry	206
6.6 The Reproducibility of Spanish Wind Energy Policy	210
6.7 Discussion	213
Main Points of Chapter Six	216

Chapter 7: Wind Energy in the United Kingdom	217
7.1 Introduction	217
7.2 A Brief History of Wind Energy Technology in the UK	217
7.3 The UK Electricity Supply Industry	224
7.4 The Non-Fossil Fuel Obligation	226
7.5 The Present Status of Wind Energy in the UK	238
7.6 The Renewable Obligation	239
7.7 The UK Wind Turbine Manufacturing Industry	247
7.8 The Role Of the UK's National Innovation System	248
7.9 Possible Applications of Danish, German and Spanish Policy in the UK	259
7.10 Policy Catalysts for Industrial Growth	262
7.11 The Potential for Future Wind Turbine Manufacturing in the UK	266
7.12 Discussion	274
Main Points of Chapter Seven	276
Chapter 8: The Contextual Development of the Wind Turbine Manufacturing Industry	277
8.1 Introduction	277
8.2 The Historical Development of the Wind Turbine Industry and the Typological Theory of Low and Abrahamson	277
8.3 The Emergent Phase of the Wind Turbine Industry	282
8.4 Application of Low and Abrahamson's Typological Theory to the Wind Industry	289
8.5 Implications of Low and Abrahamson's Typological Theory for the Wind Turbine Manufacturing Industry	297
Main Points of Chapter Eight	300

Chapter 9: The Potential for the Development of a UK Wind Turbine Manufacturing Industry	301
9.1 Introduction	301
9.2 Entry into the Industry	301
9.3 The Application of Policy in the UK	303
9.4 Future UK Renewable Energy Industry Policy	306
9.5 Policy Options for the UK	312
9.6 The Potential for Non-fiscal Instruments in Creating Competitive Advantage for a UK Wind Turbine Manufacturing Industry	317
9.7 Possible Policies to Stimulate a UK Wind Turbine Manufacturing Industry	323
Main Points in Chapter Nine	331
Chapter 10: Lessons for the Development of other Renewable Energy Technology Manufacturing Industries	332
10.1 Introduction	332
10.2 The Industrial Model for Renewable Energy Technology Manufacturing	332
10.3 The Need for a Long-term Commitment to Policy	338
10.4 Creating New UK Renewable Energy Technology Industries	340
10.5 Industrial Policy and its Effects on New RET Industries	343
10.6 Regulatory Protectionism and New Renewable Energy Technology Manufacturing	344
10.7 Government Procurement	352
10.8 Applicability of Policy Across Borders and Industries	353
Main Points of Chapter Ten	356
Chapter 11: Summary of Thesis Conclusions and Areas for Further Research	357
11.1 Conclusions	357

11.2 Further Research	362
References	366
Chapter One	366
Chapter Two	370
Chapter Three	370
Chapter Four	373
Chapter Five	376
Chapter Six	379
Chapter Seven	380
Chapter Eight	383
Chapter Nine	384
Chapter Ten	385
Chapter Eleven	387
Appendix A	388
Appendix B	389

## **Publications**

Some of the work presented here has already been published in the following fora;

Connor, P. (2001). "Wind Turbine Manufacturing Industry Reaches Maturity."  
Renewable Energy 2001(1): 63-68.

Connor, P. M. (2000). The Move to Maturity in the Wind Turbine Manufacturing Industry - Is it Happening and, if so, What are its Implications? Renewable Energy. A. A. M. Sayigh. Oxford, Pergamon. II: 1237-1240.



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<b>Tables</b>	<b>Page</b>
Table 1.1: Estimated Employment Opportunities Relating to the Wind Energy Industry	9
Table 4.1: The Danish Domestic Market 1983-1990	95
Table 4.2: Danish Wind Turbine Subsidies, 1993-1998 (DKr million)	106
Table 5.1: German Funding of Renewable Energy R&D 1978-1980	144
Table 6.1: Annual Spanish Installed Wind Turbine Capacity 1995-1999	191
Table 6.2: Worlds Largest Wind Turbine Manufacturing Company – 1998	207
Table 7.1: UK Dept. of Energy R&D Expenditures (£ Mio.) 1983-1988	218
Table 7.2: Status of planning applications (PA) for wind energy projects	235
Table 7.3: Profile of the Renewables Obligation to 2010	245

<b>Figures</b>	<b>Page</b>
Figure 1.1: Systemic environment of small, technology-based firms	19
Figure 4.1: Capacity development of wind turbines split into different ownerships	89

## Abbreviations and Acronyms

ACBE	Advisory Committee on Business and the Environment (UK)
ACORD	Advisory Council on Research and Development (UK)
BMBF	See BMFT
BMFT	German Research and Technology Ministry (also BMBF)
BWE	Bundesverband Windenergie (German Wind Energy Association)
BWEA	British Wind Energy Association
CCL	Climate Change Levy (UK)
CDU	Christian Democratic Union (Germany)
CEGB	Central Electricity Generating Board (UK)
CIEMAT	Research Centre for Energy, Environment and Technology (Spain)
CSU	Christian Socialist Union (Germany)
CTE	WTO Committee on Trade and the Environment
DANIDA	Danish International Development Agency
DEFRA	Department of Environment, Food and Regional Affairs (UK)
DETR	Department of Environment, Transport and the Regions (UK)
DEWI	Deutsche Windenergie Institut (German wind Energy Institute)
DG	Directorate General (EU)
DGW	Deutsche Gesellschaft für Windenergie (German Wind Energy Association)
DKr	Danish Krone
DM	Deutsche Mark (Germany)
DtA	Deutsche AusgleichsBank (Germany)
DTI	Department of Trade and Industry (UK)
DV	Danske Vindkraftværker (Danish Wind Turbine Owners Association)
ECJ	European Court of Justice
EEG	Erneuerbare Energien Gesetz (Renewable Energy Law) (Germany)
EFL	Electricity Feed-In Law – The German form of REFIT
EIA	Energy Information Agency (US)
ERP	European Recovery Programme (Germany)
ESI	Electricity Supply Industry
ETSU	Energy Technology Support Unit (UK)
EU	European Union
EWEA	European Wind Energy Association
FDV	Foreningen af Danske Vindmøllefabrikanter (Danish Wind Turbine Manufacturers Association)
FFL	Fossil Fuel Levy (UK)
GATT	General Agreement on Tariffs and Trade
GPA	Agreement on Government Procurement (WTO)
GW	Gigawatt
GWh	Gigawatt hour
Ir£	Irish Punt
IDAE	Institute for the Diversification and Conservation of Energy (Spain)
IEA	International Energy Agency
IPP	Independent Power Producer
IPPC	Intergovernmental Panel on Climate Change
IREDA	Indian Renewable Energy Development Agency
ITC	International Trade Commission (US)
kW	kilowatt

kWh	kilowatt hour
LEC	CCL exemption certificate (UK)
MEA	Multilateral Environment Agreement
MW	Megawatt
MWh	Megawatt hour
NETA	New Electricity Trading Arrangements (UK)
NFFO	Non-Fossil Fuel Obligation (UK)
NFPA	Non-Fossil Purchasing Agency(UK)
NFS	National Finance System
NI-NFFO	Northern Ireland – Non-Fossil Fuel Obligation
NIS	National Innovation System
nTPA	Negotiated Third Party Access
OFGEM	Office of Gas and Electricity Markets (UK)
OOA	Organisation for Information about Atomic Power (Denmark)
OVE	Organisation for Renewable Energy (Denmark)
pfg	pfennig (Germany)
PSG	private-sector governance
pta	peseta (Spain)
PURPA	Public Utility Regulatory Policies Act (USA)
PV	Photovoltaic (cells)
RE	renewable energy
REC	Regional Electricity Companies (UK)
REFIT	Renewable Energy Feed-In Tariff
RET	Renewable Energy Technology
RO	Renewables Obligation (UK)
ROC	Renewables Obligation Certificate (UK)
ROPC	Renewables Obligation Preliminary Consultation (UK)
RPS	Renewable Portfolio Standard
ROS	Renewables Obligation (Scotland)
RSO	Renewables (Scotland) Obligation
SPS	(WTO Agreement on) Sanitary and Phytosanitary Measures
SRO	Scottish Renewable Order
TBT	(WTO agreement on) Technical Barriers to Trade
TERES	The European Renewable Energy Study
TPA	Third Party Access
TW	Terawatt
TWh	Terawatt Hour
UNEP	United Nations Environment Programme
WEG	Wind Energy Group (UK)
WTO	World Trade Organisation

## **Chapter One: Introduction**

This introductory chapter has a number of aims. Firstly, it describes the basic aims and motivations of research into the area of development of renewable energy technology manufacturing. In support of this, it then provides a basic guide to the concepts that will form the building blocks of the research.

### **1.1 The Research Aims**

The basis for this thesis will be to analyse those policies aimed at helping to create new industries for renewable energy technology. More specifically it will assess the level of success which a range of policies have enjoyed in a variety of countries, taking into account any pertinent reasons for their success or failure relating to the technology and its interaction with the culture and society in which the policy is operated. This will include considerable emphasis on the operation of the policy with regard to the national innovation system of the country in which it is employed. It will assess whether policies which work for the encouragement of one kind of technology in a particular country are transferable to another country for the same technology, and equally whether such policies can be transferred across technologies. Specifically it will address the wind turbine manufacturing industry. It will analyse the goals that have been set in a number of countries for employing wind turbines, the policies that have been developed to achieve these goals and how these policies have performed once in place. More specifically it will try to determine whether policies that have been proven to be successful in one or more countries may also have the potential to be successful in the UK. Attendant to this, it will attempt to demonstrate generally that opportunities still exist for countries to develop a wind turbine manufacturing industry. This will be demonstrated, in the first instance, through

simple analysis of the actions of the most recent entrants to the sector. More interestingly, more complex analysis will suggest the possibility for a change in the industrial phase of the industry, and that this is demonstrative of the potential for market access which goes beyond the simple analysis of mimicking the most recent successful industry entrants.

## 1.2 Renewable Energy Technology Manufacturing and the UK

At the beginning of the year 2000, the UK had 356 MW of wind power online (WPM 2000), ranking it at seventh place for capacity installed on a list of the world's countries. However it has no significant domestically-owned manufacturing capability, and the total installed capacity has only been increasing by very small increments in the years up to 2000, though this is set to increase more rapidly in 2001.

With regard to photovoltaics, the biggest manufacturer in the world is the UK-owned BP Solar. Despite its ownership, it has no manufacturing facilities in the UK, and there is, in fact, only one UK-based PV manufacturer. Clearly this is an undesirable state of affairs for the UK. UK Government policy suggests that encouraging the uptake of RET's is desirable for a range of reasons, these include;

- Increased security and diversity of supply
- Environmental merits with regard to climate change policy
- Capacity to contribute to rural development, and
- "Assisting the UK renewables industry to become competitive in home and export markets and in doing so provide employment in a rapidly expanding sector."

(DTI 2000e)

One of the central strands of this work will be to analyse the UK's policy in

attempting to achieve the last of the aims listed, what effect various policies have had and why.

It is regularly assumed by a number of industry observers that the UK has missed out on the opportunity to develop a significant domestically-owned wind turbine manufacturing industry (e.g Greenpeace 1998b). This thesis critically analyses this assertion and attempts to establish an argument that this is not necessarily the case, alongside recommendations from various actors within the field as to possible courses of action that might enable such an industry to develop.

This leads to the central hypothesis of this thesis, that an incipient change in the industrial phase of the wind turbine manufacturing industry will provide fresh opportunity for new actors to access the market. In this thesis, the impact of this change is assessed with regard to the current industry as a whole and to the potential it offers for new actors, most notably UK industry. The thesis also considers potential implications for more established actors.

This hypothesis leads on to the more practical question of possible courses of action available to these potential actors to exploit this new opportunity. The thesis particularly addresses the potential for political support within specific relevant countries as well as generically, though again there is particular emphasis on the UK. The UK is selected as an example of a country where policy has failed to aid the development of an industry, and for other reasons which will be discussed in greater depth in a later chapter.

### 1.3 Introduction of Issues and Definition of Terms Relevant to this Research

This chapter attempts to define and describe some of the terms to be used throughout the thesis, including brief descriptions of what renewable energy is, what



renewable energy technology (RET) is, and why it is desirable. It will address the size and value of the markets for RET and consider what expansion is predicted for the future. The chapter will also provide an explanation of terms such as national innovation system which are relevant to understanding of the eventual conclusions.

### 1.3.1 Renewable Energy

Renewable energy refers to ‘those forms of energy which occur naturally and repeatedly in the environment’ (National Audit Office 1994), that is, those forms that are effectively replenished even as they are depleted. Renewable energy sources include the sun, waves, wind, tides, plants and water falling under gravity.

Geothermal energy and waste-to-energy systems are often also included in the group, though they do not technically match the sustainable nature of the other sources.

While the renewable energy sources are continuously replenished they are also ‘flow-limited’, that is, only a certain amount of energy is obtainable from the source at any time, for example, the sunlight falling on a unit area has an effective upper energy limit.

While different RET’s can be used to fulfil different energy needs and can be used to provide both electricity and heat, this piece of work will largely concern itself with the electricity generating technology of wind. This having been chosen for the reasons already outlined above.

To give a brief description of wind technology; wind energy is an indirect utilisation of solar energy. The sun heats up air masses irregularly, differences in temperature cause these air masses to shift . These moving air masses cause revolution of the wind turbines blades, and the movement of the blades drives the

turbine itself via a gearing system to produce electricity. The energy output is thus linked to the prevailing wind speed.

Whilst there is a small market for turbines rated around the 1kW-10kW range, generally for domestic use, the market for larger scale machines, typically in the range of 250kW up to multi-Megawatt machines is much more significant economically and will form the focus of this study.

### 1.3.2 Reasons for Implementing Renewable Energy

The reason most often cited for the desirability of encouraging the use of RET's is their relatively low level of environmental impact. Whilst wind turbines have been opposed on the grounds of loss of visual amenity and the noise they produce, and photovoltaics for the large amount of land they might require, in comparison to the fossil fuels used in conventional power stations, renewable power generators have considerably less environmental impact (IEA 1998; Dincer 1999; Krewitt, Heck et al. 1999) in terms of pollutant emissions inherent to their use. Replacement of fossil fuel generation with renewable energy generation means a reduction in the emission of sulphur dioxide, carbon dioxide, methane and a range of oxides of nitrogen. Together these pollutants are collectively responsible for a range of environmental problems including acid rain, creation of ground level ozone and smog, and are linked with global climate change. Fossil fuel power stations have been linked to the deaths of up to 50,000 people in the US annually via the causation of respiratory disorder (Dockery and Pope 1994; Moore 1997), and to have caused damage to human health, building materials and crop production to the value of US\$70 billion in 1990 alone (Krewitt, Heck et al. 1999).

The second reason commonly offered for increased development of renewable energy sources is increased security of energy supply for the country in which installation takes place. The oil crises of the 1970's, for example, led to anxiety on the part of many Governments whose economies were dependent on oil importation, which resulted in large increases in funding for renewable energy research and development. Typical of this trend was Denmark - at the time of the first world oil crisis in 1973, 92% of Danish total primary energy consumption was provided through the burning of imported fossil fuels (Danish Energy Agency 1992). Obviously, the placing of restrictions on supply of oil by outside agencies, or the possibility of continued price rises, had serious implications for the Danish economy. The situation led the major political parties to rapidly achieve a consensus with regard to a long term energy policy, and control of the energy sector and both long and short term planning within it were rapidly brought under government control. One of the major problems for Danish energy policy was the lack of indigenous energy sources. Denmark has no coal and, at the time, the oil and gas fields over which it had ownership were not capable of being easily exploited. Denmark did however have the geography which meant it had some of the best wind resources in Europe, as well as some history of exploiting these resources, hence, wind power and its development were introduced as part of the country's long term energy plan.

By using more domestically sourced energy nations increase energy independence and security of supply, they also provide a benefit by reducing importation and the costs that go with it, thereby acting to benefit a nations balance of payments. A press statement from the Irish Government in 1996 calculated that each

MWh generated from wind (or any other renewable source) displaced the need to import up to I£100,000 of oil - equivalent to about US\$110,000 (Stagg 1996).

The third reason commonly given for development of RET's, and the one which will largely form the focus of this thesis, is for the "encouragement of internationally competitive industries" (DTI 1994).

This line is taken from a UK Department of Trade and Industry document concerning policy on encouraging the growth in the use of renewable energy. However, the UK is only one of an increasing number of countries which have expressed their desire to stake a claim in the newly developing RET industries and which have shaped appropriate policies with this aim.

### 1.3.3 Social and Economic Motivations for Renewable Energy

The reasons for a government wishing to develop a domestic RET manufacturing industry are plentiful. During the last few years a range of organisations have produced estimates of what future markets will be worth, and this is in addition to the figures for the present level of the industry.

The Energy Technology Support Unit, in a report for the UK's Department of Trade and Industry, quoted figures that suggested that with current policies in place, the world wind industry would be worth £36 billion by 2010, and £125 billion by 2020.

Christopher Flavin, author of a number of books on the subject of renewable energy, estimated the world wind energy technology manufacturing industry to be worth US\$2 billion per annum in 1996, and to be growing at a rate of 25% annually (Flavin and Lenssen 1992), Flavin also estimates the world photovoltaic cell market to

have been worth US\$340 million in 1988 and to have risen to US\$900 million by 1996.

Shell announced in 1997 that it estimated that the total renewable energy market could be worth US\$148 billion by 2020, alongside their intention to invest US\$500 million in gaining access to these markets (Shell 1997).

The European Parliament has stated it wishes to double renewable energy use within the European Union and wishes to achieve this as part of a 30% increase in energy investment, a potential extra investment of ECU 74.1 billion. The Parliament suggests this could lead to the creation of an ECU 17 billion p.a. export market centred around the EU.

In addition to the purely financial benefits of a share of the burgeoning RET manufacturing markets, the new industries are particularly labour intensive and have the potential to create a significant number of new employment opportunities, for example, the European Parliament's suggestion to increase energy investment mentioned above was estimated to potentially lead to a net creation of up to 500,000 new jobs (European Commission 1997 pp12). The European Commission's White Paper on Renewable Energy (European Commission 1997, pp12) details the European Wind Energy Association's predictions that the wind sector could be employing 190,000-320,000 people by 2010 if 40 GW of capacity was to be installed across the continent. A report by Greenpeace, 'Windforce 10', calculated that each Megawatt of turbine capacity manufactured generates 17 job-years, plus another 5 job-years for installation, noting that the manufacturing figure would probably drop to around 15.5 job-years/MW by 2010 due to increased productivity, and would further drop to an estimated 12.3 job-years/MW by 2020. Applying these estimates for employment

potential to the projections for wind turbine usage gives a potential for 500,000-600,000 jobs to be created by 2010, based on a projected installation of 40,000 MW by that year (EWEA/FED/GI 1999; Renner 2000). Other estimates for the level of jobs created by increased wind turbine usage have been published by the European Commission and by Greenpeace Germany. The European Commission estimated that the installation of a MW of wind capacity creates jobs for between 15 and 19 people . Applying this figure to the then EWEA (European Wind Energy Association) projections for the likely installed capacity up to 2020, gives the projections detailed in Table 1.1;

Table 1.1 Estimated Employment Opportunities Relating to the Wind Energy Industry

Year	EWEA Goals MW	Jobs Created: Man-years
1996	3,500	
2000	8,000	72,000
2010	40,000	512,000
2020	100,000	960,000

(European Commission 1999, pp103)

Renner reports a publication from Greenpeace Germany suggesting a figure of 14 job-years created for every MW of installed wind capacity (Renner 2000). Renner also points out that these figures apply to onshore wind, and that the level of jobs associated with the installation of offshore capacity is likely to be the higher than these estimates.

It should be noted that the EWEA has since altered its estimates of the potential capacity that might be installed, increasing them by 50%. Should this higher potential be achieved, the obvious results would be a requirement for a greater level of investment and the creation of more job opportunities. It should be noted though, that this would be likely to lead to more rapid improvements in productivity, so that it

can not be assumed that a 50% increase in the figures for installed capacity would correlate with a 50% increase in the employment opportunities created.

Another recent policy, the USA's million solar roof plan has been estimated to have the potential to create 70,000 jobs (US Department of Energy 2000). Whilst the White Paper shies away from drawing any firm conclusions regarding the actual potential, it acknowledges that renewable energy technologies have the potential to create up to a total of 350,000 job opportunities by 2010 (European Commission 1997, pp13). The White Paper makes no comment as to the likely geographic dispersal of any jobs that arise from the increased use of RET.

The world wind industry was calculated to employ around 30,000 people in a 1995 survey (FDV 1995), approximately 12,000 of which were employed as a result of the Danish industry. This figure for Denmark was estimated to have increased to 15,000 by the end of 1999 (FDV 1999). The 1995 survey also estimated that approximately 10,000 jobs stemmed from the German industry, with the rest scattered around the world but with significant numbers in Spain, the Netherlands, and the US. The German Wind Energy Institute (DEWI) calculated that due to rapid expansion in the wind energy sector during 1999, 31,350 people were employed full time in Germany alone during that period (DEWI 2000). DEWI suggest that approximately one third of these are jobs directly related to wind energy, whilst the rest are created indirectly in other industrial sectors which support the efforts of the wind energy sector.

Clearly there are a range of significant benefits to act as the stimulus for countries and companies to act to gain a share in the potential renewable energy manufacturing marketplace. There are a range of policies which may be effected by

both of these groups of actors, and their agents, to facilitate access. The policies employed by different countries to try to stimulate their renewable energy manufacturing industries have varied strongly, Mitchell suggests that this is largely due to the differing characteristics of each country's national innovation strategy (NIS) (Mitchell 1994).

#### 1.3.4 Renewable Energy Manufacturing Industry

The market for renewable energy technologies has been steadily increasing over the last few years. In 1999, the wind turbine manufacturing industry had an estimated combined sales of approximately \$4 billion (DEWI 2000), and combined sales of photovoltaics were about \$1 billion (Shell 1997), though estimates vary. Both of these markets are set to increase at rapid rates, with estimates generally in excess of a 20% increase annually in the near future. In 1999, worldwide wind turbine installation was 51% greater than it had been in the previous year (DEWI 2000).

In June 2000, the major Swiss-Swedish multi-national ABB announced its entry into the renewable energy sector, suggesting that its combined share of the sector as a whole could be worth \$1 Billion within five years. The German Government has initiated policy to exploit what it estimates as a potential 100,000 MW demand for wind energy generators (EEG 2000). Applying a typical price for wind energy generating capacity of £800-£1000/kWh, this gives a figure for the total expected investment of £80-100 billion.

In the long term, Shell have gone as far as to suggest that renewable energy will account for 50% of all energy use by the middle of the 21<sup>st</sup> Century (Shell 1996; Herkströter 1997; Shell 2001). If this prediction should come to fruition, it could



require investment exceeding \$1 trillion, (Dunkerley 1995) spread over the period 2000-2050.

The UK's Department of Trade and Industry, in the supporting analysis for its proposals for a new mechanism to support renewable energy and the development of renewable energy technology cited a number of estimates for the potential economic investment that various technologies might engender should they become economic, based on the worldwide potential exploitable resource (DTI 2000c).

The DTI calculates that the world turbine market would generate only £2.5 billion in 2001, rising to £3.0 billion by 2006. These figures however, seem to rely on an estimated rate of expansion that is already proving to be too low. The DTI also estimates that the total UK share of the world export market was equal to only £20 million for the year 1994/95, though they suggest that this could be expected to rise, though it is difficult to find very credible evidence in the report to justify faith in such an expansion (DTI 2000b).

The DTI report practically writes off the potential for an export market in tidal stream technology, on the basis that the high cost makes it inappropriate for any but a very limited number of sites (DTI 2000d). It does not seem to give consideration to the possibility that the price might come down as a result of initial subsidised use, and the possible benefits of R&D. This is distinctly at odds with the opinion expressed by the House of Commons Select Committee on Science and Technology, which in its Seventh Report on Wave and Tidal Energy supported the view that Tidal Stream, alongside wave energy, could be at the heart of an 'enormous potential export market' (House of Commons: Select Committee on Science and Technology 2001).

The DTI analysis is itself, distinctly more optimistic with regard to wave energy. The report assesses wave energy technology as having the potential to deliver 2,000 TWh per annum on a global basis, and the investment needed to achieve the capacity to produce this at £1 trillion. (DTI 2000a).

There are thus clearly a number of attractive or potentially attractive markets to access and exploit.

#### 1.3.5 Wind Energy Industry

Wind Energy is the most developed of the new renewable energy technologies. The corollary of this is that the technology, and the industry structure that supplies it, are the most mature in comparison with the other technologies. As a result it provides more data on the nature of the development of such an industry, on the way it has grown and how it has been supported. It also provides more examples for success and failure of entrepreneurial efforts and for the level of penetration of respective national efforts.

Despite this relative advancement, the industry still has significant room to expand and has yet to become fully mature. Thus it may still have the potential to change and may still offer new entrepreneurial opportunity. Assessing these possibilities will form an important part of this thesis.

#### 1.3.6 Wave and Tidal Stream Energy

Wave and tidal stream technologies are at a much earlier stage of development than wind, both with regard to the technology and the maturity of the respective industry. They seem likely however, to be the technologies that have the most in common with wind energy, most notably now that the development of wind is

increasingly focussed on offshore opportunities. Further similarities are likely to include the level of sophistication of the technology, and various aspects of the industrial model relating to the development of the technology and the constraints that factors such as availability of resources have in determining which nations support the technology. In turn, this affects both the policies and mechanisms for supporting the growth of the technology, marketplaces and industries which are applied with respect to each technology.

Thorpe (Thorpe 1999) estimates a worldwide wave energy potential of 2TW, sufficient to generate 2000 TWh/year, and suggests this would require an investment of £500 billion. Thorpe also suggests costs for some projects may be as low as 5p/kWh (Thorpe 2000). Capacity so far is largely confined to pilot plants in Norway, Portugal, Denmark, Ireland and the UK, though in the UK, three projects were awarded contracts within the third Scottish Renewables Obligation Order Three (SRO-3) (Petroncini and Yemm 2000). The three projects range in size from 43kW to 500kW, and are thus relatively small. One of the wave projects is now generating (OFGEM 2001).

Tidal Stream is less developed, there are currently no commercial plants planned and even the development of pilot plants is at an early stage. The likely world capacity has yet to be calculated, though the resource is likely to be significant (Fraenkel 2001).

### 1.3.7 Photovoltaic Energy

Photovoltaic (PV) energy has been the subject of considerable research in the last fifty years, nevertheless, the PV industry can be regarded as being in a relatively immature state. Despite, this the technology is regarded as likely to be one of the

most significant sources of energy in the future (Derrick, Barlow et al. 1995; Shell 1996; Herkströter 1997; Greenpeace 1998a; Shell 2001).

The nature of this research is such that it looks to the wind industry for much of the evidence of the successful and unsuccessful use of policy, and its conclusions are drawn from examples relating to the specific industrial model of the wind turbine industry. The differences between the wind and PV manufacturing industries mean that possible lessons from one for the other are considered in only very general terms.

#### 1.3.8 Barriers to Renewable Energy

The nature of each individual national innovation system will have an impact relating to the creation of barriers to the use of renewable energy generation, they thus affect the overall amount of sales accessible to the world-wide industry. This is not necessarily to say that all barriers stem from the particular NIS, some may be of a generic nature.

It has been demonstrated that the creation of a strong domestic market is one of the key factors in allowing a particular industry to achieve success outside its home country. On the general level, evidence has been presented for this by Porter (Porter 1990b; Porter 1990a) and others (Hout, Porter et al. 1982) and on a more specific level, Gipe suggests that “one of the keys to Denmark’s success [in the world market] has been a consistent national policy resulting in a strong domestic market for wind energy” (Gipe 1995). Furthermore, the recent Dutch White Paper on Renewable Energy (Dutch Ministry of Economic Affairs 1997) suggested that a strong domestic market would engender a self-strengthening cycle as it leads to more international sales which in turn acts to reduce the costs of turbines domestically and generate a stronger home market.

The barriers to the increased take up of renewable energy technology have been discussed in a number of forums (Madsen 1990; Mitchell 1994; Grubb 1995; AEP 1996; Street and Miles 1996; Eufores 1997; Koch 1998; Painuly 2001; Derrick, Barlow et al. 1995; Oliver and Jackson 1999) but will be summarised here for the purposes of completeness.

Documents produced by both Derrick *et al* (Derrick, Barlow et al. 1995), and by ECOTEC (Eufores 1997), suggests there are five basic categories of barrier, these are;

- Political Barriers; including lack of political motivation to support the market development required, arising from a lack on the part of all significant political actors and a number of other actors relevant to the field. Also includes lack of industrial commitment to the necessary infrastructure to develop renewable energy systems to the achievable potential.
- Legislative and Administrative Barriers; includes a lack of an appropriate legal framework, a lack of regulations for specific renewable sources, including problems due to planning regulations and access to national grid supply networks both in terms of protection of vested interests and on a purely technical level.
- Financial and Fiscal Barriers; lack of appropriate financing for long term projects, while in many ways a manifestation of national financial systems, the problem is common enough at national level to be regarded as the rule rather than the exception. A further problem is the financial power of the entrenched generators with which new generators have to compete.

- Technological Barriers; technological obstacles relating to research, development and demonstration.
- Information, Education and Training Barriers; the general lack of awareness of renewable energy potential and the possibility for using renewable energy generation at all levels and scales. Also a problem in terms of developing a base of trained operatives to support the growth of manufacturing industry.

Put in this context, it perhaps sounds more plausible that the barriers can be overcome through acts of political will. It must be borne in mind however, that as the barriers exist as a function of the respective NIS's, that the barriers will vary from country to country and that their existence is a reflection of the particular nature and identity of each country. This is not to suggest that the barriers may be impossible to overcome, though it does allow that this might be a possibility. Further, it means that the responses needed to surmount a particular obstacle in different countries, even if they are apparently similar, will not necessarily engender the same results. Again however this is not too imply that this is necessarily the case and in some instances similar policies may be internationally transferable. As a further qualifier it should also be borne in mind that the same obstacle may respond to a range of different solutions. An effort to identify some of those policies which may be capable of successful transference, and perhaps those that are not, will form part of this piece of work.

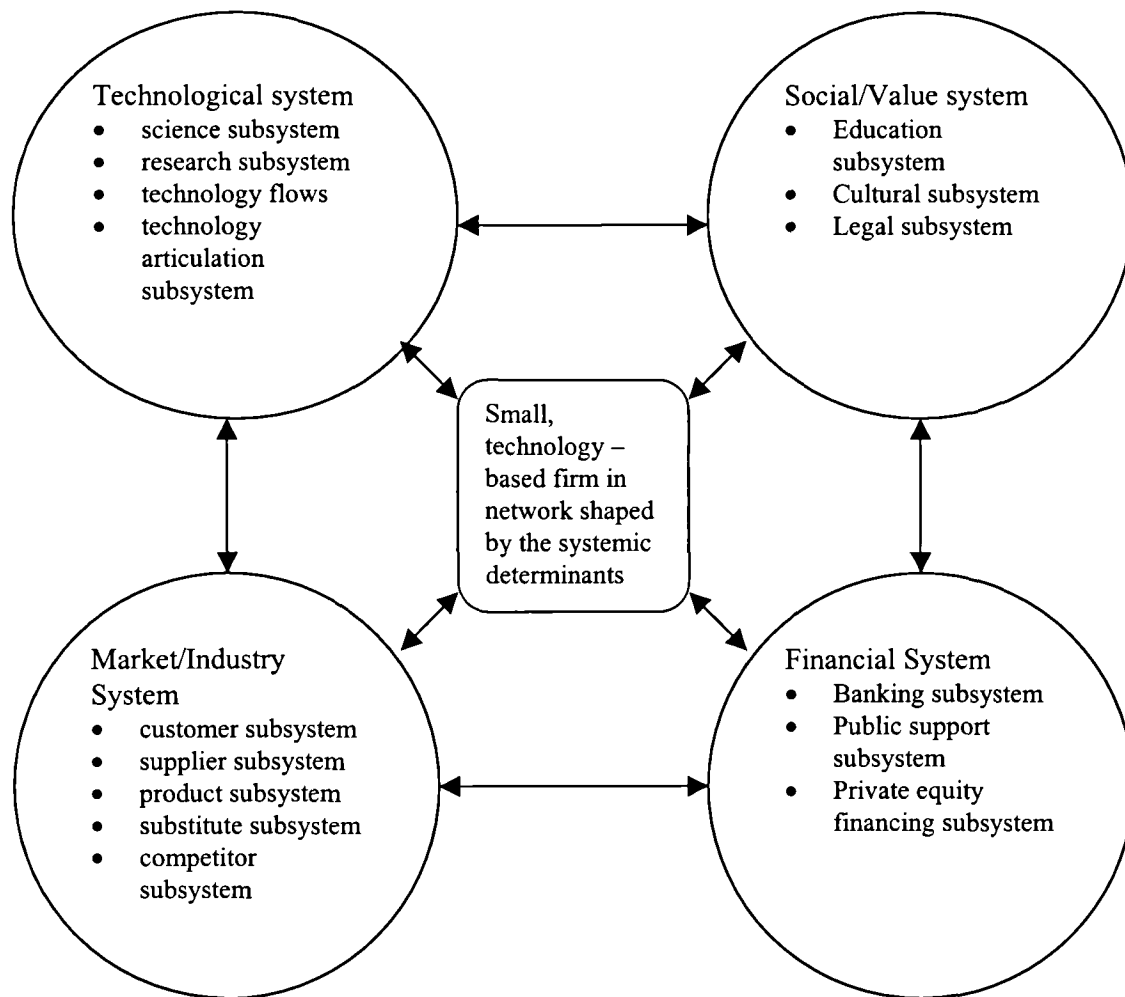
Whatever the nature of the barriers however, the political will to deal with them is cited as essential to their removal, and to the expansion of the relevant technology. One of the precepts of this thesis is that the creation of industry can act as

a driving force for the generation of increased political interest through the creation of a political constituency with interests in the continued stimulus of the industry. To some extent then, creating policy which drives industry should act to increase political interest, and this in turn should act to assist in continuing the expansion of that industry. The result of this is to allow the industry to continue to grow, and a form of feedback loop may be set up wherein the industry becomes self-sustaining – though this is not to suggest that an industry that does become self-sustaining will necessarily wish to divest itself of political and thus regulatory support.

#### 1.3.9 National Innovation Strategy

The national innovation strategy of a country is made up of a number of different systems with internationally varying characteristics. Various definitions of what a national innovation system is, and what implications each has for the industry of each country concerned, have been published (Freeman 1988; Dalum 1992; Freeman 1992; Lundvall 1992; Nelson 1993; Shane 1993; Walker 1993; Wever and Allen 1993; Dalum 1994; Patel and Pavitt 1994). Laamanen and Autio define the NIS as being the product of four separate systems; the technology system, social value system, market/industry system and the financial system (Laamanen and Autio 1996). They place the existence of small and medium sized enterprises within a network created by these determinants of the NIS. Each of the four systems within the NIS break down further into a series of subsystems which each reflect various aspects of those factors within a country which can act to drive, or to hold back, development of new technology and technological processes within a nation. Each system can best be expressed in terms of its component subsystems, as shown in Figure 1.

Figure 1: Systemic environment of small, technology-based firms



(Laamanen and Autio 1996)

To continue to use the definitions proposed by Laamanen and Autio, the technological system is made up of the science subsystem, research subsystem, technology flows and the technology articulation subsystem. The social/value system comprises the education subsystem, cultural subsystem and legal subsystem. The market/industry system is made up of the customer subsystem, supplier subsystem, product subsystem and competitor subsystem. Finally the financial system is a combination of the banking , public support and private equity financing subsystems.



Obviously, as each of these subsystems, and thus the systems themselves, differ from country to country, the circumstances in which small technology based firms develop, and in which any new technology itself develops, are variable. Thus a development process which is successful in one country is not necessarily transferable to another country. The same applies, though perhaps to a slightly lesser extent, to larger companies. This will be demonstrated later in this thesis as the specific histories of the development of wind turbines in different countries are considered in some depth. It should also be noted however that this statement does not imply that policies applicable in one country may not be applicable in another. Part of this thesis will be investigate whether any of the policies employed successfully in developing technology in those countries pioneering renewable energy manufacturing, can be transferred to aid development within a different NIS and to what extent such a transfer is applicable.

Clearly, some of the subsystems will have considerably more influence than others within the individual NIS's and with regard to particular technology strands. Equally what works for one form of technology in one country may be entirely inappropriate for another kind of technology in the same country. A notable example of this is the lack of small scale lending structures in the UK (Mitchell 1994; Hameri 1996), which has led to problems in obtaining financing for renewable energy projects in that country. The same UK NFS however, has proved more successful for the support of combined cycle gas turbines. The different financing systems of, for example, Denmark or Germany have been more appropriate to the scale of typical RE projects, and this is likely to be one of the reasons for the greater success of these technologies in those countries.

The national financing system can play one of the most significant parts in determining the potential for success of new technologies within a country's NIS. Mitchell suggests that the banking subsystem is of extreme significance with regard to the penetration of RET's, presenting as evidence a comparative assessment of the more flexible banking systems of Denmark, Germany and the Netherlands. Mitchell suggests these have structures allowing smaller amounts - £300,000 in Mitchell's example - to be loaned more easily, and with perhaps a slightly longer term payback period than with the UK system, which does not have these characteristics (Mitchell 1994).

The public support subsystem refers to the methods through which new technologies can be brought into wider use via programmes devised by government, a wide range of such programmes exist within the renewable energy field. It can quite easily be argued that the subsystem can be linked to the social/value system of the NIS, as they can be sensitive to the political direction of a country.

The UK's NFFO and Germany's Electricity Feed-in Law are representative of schemes within the public support subsystem. This suggests that it is possible to provide effective support in different ways - though it can be argued that these two schemes have different aims, and thus different success criteria, and are therefore not necessarily comparable. It should be noted however, that such different approaches may infer a variety of implications for the path along which the technology develops. To continue to use the comparison above as an example, the German method may prove easy to manipulate to favour German manufacturing industry growth or to provide more continuous growth than the UK programme.

The technological system and its subsystems also have considerable impact within the field of RET development. Obviously, the science and the research subsystems, their financing and structure, or lack of same, hold enough significance to control the existence and development of new technology. In terms of wind energy, while the basic scientific research has been carried out and the existing technology is of a more advanced nature, the research process is still a relevant one. In the case of photovoltaics, wave and tidal stream technologies, both are very relevant.

Both the science and research subsystems are extensively linked to other parts of the NIS, including the education and the cultural subsystems, by dint of their close relationship to the political philosophies in the respective countries.

Technology flows, in this context refers to the pattern through which technologies transfer from the basic research stage to that of becoming useful to industry, whether it is from an outside research agency, from industry itself or from a collaboration of the two.

There are several examples of technology flows of this kind which help to demonstrate the two most apparent methods for transfer. Firstly, Japan's Ministry of International Trade and Industry (MITI) is the leading example of an agency which has co-ordinated a programme to promote basic research and ensure its results effectively transfer over into industrial domain, though it should be noted that the role of MITI is more complex than might at first be apparent. For example, there is evidence that private companies focus their efforts on their private research, and participate in MITI projects as a way of learning about the areas in which their competitors are working. Nevertheless, the system seems to have enjoyed a high level of success. The promotion on the national level is mirrored by government

departments in other countries which have experienced variable degrees of success in achieving clear flows of technology, for example, the US Department of Defense, within its respective NIS (Freeman 1987; Freeman 1988).

#### 1.3.9.1 The Impacts of the Social Sub-System

As has already been described, it is possible for the social, or value, system component of an NIS to also have serious implications for the path of technology development (Porter 1990a; Porter 1990b). Both Porter (Porter 1990a; Porter 1990b) and Nelson (Nelson 1993) suggest that education is one of the key factors in an industry, and a country, achieving success, most especially with regard to international markets. Porter's Competitive Advantage of Nations presents a significant volume of evidence that advanced level training in relevant key areas can be a significant stimulus to expansion and continued success of major, nationally based industries in the international marketplace (Porter 1990a).

The cultural subsystem of an NIS could be regarded as including the national political structure and this would imply significant potential to affect the conditions of the whole innovative system. Nelson's survey of a range of different national innovation systems (Nelson 1993) however leads him to conclude that the origins of most NIS's have a basis in the past. Nelson suggests that newer nations such as Israel, Taiwan and Korea show signs of continuity in their NIS's throughout their short histories but also that countries with longer industrial histories, such as Germany, Japan and France also display a strong degree of 'institutional continuity'. Nelson cites the US as the only country with significant history to have undergone any major degree of institutional change, this in response to the second world war when the nature of funding provision for university and defence R&D was

significantly altered. Nelson points out that even after suffering full-scale defeat in the second world war, the nature of the German and the Japanese NIS's remained remarkably consistent throughout and have continued to do so up to the present.

This phenomenon can perhaps be regarded in two ways, firstly as an example of continuity, but secondly, as an example of the inability to alter an NIS without a very major stimulus. This second interpretation of course, has important implications for any country with a less successful NIS, and with regard to the lack of an ability to be able to change and adapt in the future.

Shane (Shane 1993) suggests that there are particular cultural influences that are extremely relevant in informing national innovation processes, and thus in rates of national technological change.

The final aspect of the social system, the legal subsystem also has some important implications, the subsystem again has strong links with the cultural subsystem and can act as a reflection of this. Issues arising from it include attitudes relating to property, including land and its uses and amenity, as well as to trade, unions and competition.

Finally, what makes up the market system of an NIS essentially speaks for itself, the five subsystems named in Laamanen and Autio's model relate to the nature of the behaviour of the actors within the markets and to some extent to the relationship between them.

#### 1.3.10 The Nature of Companies Involved in Renewable Energy Technology

The differing NIS's of the countries addressed in this thesis will be considered in terms of the scale and nature of the effect they have on the birth, development, growth and maturation of their respective renewable energy manufacturing industries.

It will also attempt to take into account the interaction of the different countries concerned.

Another factor which will be relevant to the topic with regard to the national innovation systems is the size of the companies concerned with the innovation process. Larger companies are advantaged in a number of ways, most notably they are more capable of being able to attract financing. They have greater access to a wider range of financial instruments and their substantial capital helps them to secure additional finance more easily. Larger companies can thus more easily side-step the problems that can arise due to particular national financing structures.

Large companies are also capable of providing support for their own research, thus circumventing or partially circumventing any deficit accruing from inadequacies in the technological system of a country's NIS.

Large companies as a result of their financial status, their economic importance, and the number of people they employ, are also able to exert a degree of political influence such that operating conditions are more suitable to the needs of the company. It is possible that there is also a correlation between the size of companies involved in particular industries at particular times in their industrial development.

The difference between large, even multi-national companies and small and medium sized enterprises is particularly relevant to RET manufacturing with a regard to a comparison of wind and PV manufacturing. At present, wind turbine manufacturing tends to be dominated by smaller companies such as the Danish turbine companies, Vestas, Nordtank, Bonus and Nordex, which converted to the industry after previously operating in the agricultural engineering field (Krohn 2000). There has however been an increasing interest in the industry on the part of larger

concerns. Perhaps, most notable was the announcement by the Swiss-Swedish conglomerate ABB, that it would be diversifying its interests to include wind turbine manufacturing amongst a whole raft of other RET's. The potential implications of this development will be discussed at length in later chapters concerning the potential change in the industrial phase of the sector. The major actors in the photovoltaics manufacturing industry seem to be the emerging subsidiaries of multi-national companies, for example BP Solar and Siemens in Europe and the US, and Sanyo and Kyocera in Japan. Obviously this difference in the types of company operating in the two markets may have an impact on the way that their respective industries and their markets develop, and this will introduce additional factors to be taken into account in comparing the two industries and in attempting to assess whether any of the lessons learned from the growth of one can be transferred to the other. Whilst this might appear to be a factor which would mitigate against the possibilities of applying a successful policy from one sector to another sector, it is suggested that one of the possible directions for the likely future movement of the wind turbine manufacturing sector is that larger companies are likely to become involved, thus the eventual mature state of one industry might reflect the other to some degree. This possibility will also be considered in a later part of this thesis.

Notably, the newly emergent technologies for the utilisation of wave and tidal stream energy also appear to be being developed by smaller companies.

## Conclusion

There are clearly a considerable range of factors affecting the successful development of industries in the renewable energy sector. Consideration of how different policy instruments have impacted on the efforts of nations to drive the

establishment of an industry and maintain its growth will have to account for this range in reflecting on how such policies might apply in other countries. This will be central to the work detailed in the following chapters.

#### Main Points of Chapter One

- There is a world market for wind turbines worth at least \$2 billion p.a. and likely to expand rapidly in the next twenty years.
- The UK presently has no significant, domestically owned wind turbine industry.
- The UK has a long term policy commitment to developing internationally competitive renewable energy industries.
- Penetration of renewable energy technology in different national markets is dependent on a wide range of factors relating to a country's national innovation system and to the policies in place in the particular country.



## **Chapter Two: Methodology**

### **2.1 Research Aims**

The focus of this research is an investigation and analysis of the development of renewable energy technology manufacturing industry.

Traditional hydro aside, wind energy is clearly the most mature of these industries and has the largest market at present. Wind turbine manufacturing was thus the obvious choice as the focus for the study of the growth of a renewable energy technology manufacturing industry.

Within this context, the main aim was judged to be an analysis as to what factors and methods had enabled the successful growth of RET manufacturing industry in those areas in which they had so far developed. Further, it was thought to be important to assess whether these would also be applicable to driving the development of similar industries in countries where they had not yet successfully arisen. The UK was then chosen as the specific country for this application, for reasons described below.

To clarify, the work assesses the possibilities for the capture of domestic and international market opportunities for RET's, by UK manufacturers. The research addresses the development of wind energy specifically, but also attempts to assess what lessons might be learned from wind energy technology for application to other RET's, and to the development of manufacturing opportunities for them. The natural progenitor for classification of such a policy is to identify those policies which would allow the creation and survival of those UK manufacturers in the first place.

The decision to focus the research on the UK was a direct result of the wish to focus on the application of policy aimed at the creation of industry, as distinct from the simple creation of a market. The development of new industry, and of the policies

which aid its creation, can in many ways be regarded as an essential function of government, though clearly other actors are intrinsically involved. Such policy is thus essentially nationalistic in that it is rooted in meeting the needs of a particular political constituency, and that it has to reflect the specific social and economic situation of the nation which is utilising a particular policy. Rooting the analysis of renewable energy industrial policy in the context of the experiences of a single country, and assessing the potential of policies for creating RET industries in that country allows conclusions about the possibilities for generic uses of policy, and about the limitations of situation specific policies for crossing national boundaries.

## 2.2 The Choice of the UK as the Focus for Study

The UK has instituted a number of policies aimed at creating a market for RET, albeit that it could be argued that this has been with only a limited degree of success. Despite this, and also despite the avowed policy of wishing to aid the development of internationally competitive RET manufacturing industries (DTI 2000), the UK has yet to establish any significant industry in the sector. This makes the UK ideal for a discussion both of failing policies, and of the potential for the application of policies that have been successful in other arenas.

The choice of the UK was reinforced on the basis of the geographical location of the researcher, the easy availability of materials relating to this and to the limited language skills of the researcher. The choice also enabled the research to more closely relate to the aims and objectives of the funding research council.

It rapidly became evident that the question as to whether it is possible for the UK to develop RET manufacturing industry, and specifically, a wind turbine manufacturing industry, is actually a question in two parts. Firstly, does an

opportunity exist, and secondly, if the opportunity exists, what actions would need to be taken to assist the creation of an industry and, once created, to enable it to access the market.

These aspects together lead to a third issue which must also be addressed, that of judging the applicability of policies to another country. The UK was chosen as the country to which the question of reproducibility of policy would be applied most specifically.

### 2.3 The State of the Wind Industry

Analysis of the wind turbine market at the end of 1997, that is, at the beginning of this research process, clearly showed the identity of the dominant manufacturers in the wind turbine sector, and by implication those that had experienced the most successful circumstances.

Danish companies were clearly the sector leaders, with German companies also enjoying some success.

Other significant manufacturers at this point were identified as American, Japanese and Dutch. In the case of the US and Japan however, success was confined to a single example in each. The study was determined, from an early stage, to be an analysis of those policies which helped to create and support a manufacturing sector. It was believed from an early stage that a domestic market was essential to sectoral success, a viewpoint backed by general industrial analysis (Porter 1990), and borne out by the evidence from the turbine industry itself.

This study concerns itself to some degree with the creation of a market, but more fundamentally it addresses the variety of policies aimed at the creation of an industry to service that market, and the level of success that such industrial policies

enjoy. It is important, it is suggested, to bear in mind that the creation of a market and the creation of an industry are not the same thing, and that policy which acts to create a market does not necessarily lead to a corresponding industry benefiting the policy initiator. This conception will be emphasised through the presentation of evidence provided in later chapters.

Applying this hypothesis, it was judged that the main subjects for this study should be those nations with both a thriving domestic market and an already existing manufacturing sector.

The Netherlands was rejected as a possible subject for a case study on the basis that the Dutch market has effectively entered a state of stagnation and has been expanding only slowly in recent years. Japan was also rejected on grounds relating to the paucity of its domestic marketplace and, additionally, because of the practical difficulty of obtaining material concerning its industry and policy owing to language constraints.

The United States was also initially rejected as a subject due to the stagnant state of its domestic market. Whilst this market has become considerably more dynamic in the last two years, this has yet to spawn a significant number of domestic manufacturers. The choice of the US as a suitably relevant focus for this study is also mitigated against by the disparate nature of policy regarding market creation which results from its federal nature. The US will, however, receive some attention on the basis of the re-emergence of some states as significant purchasers of turbine technology, and with regard to the particular method of encouraging the growth of renewables that is prevalent there, that is, the Renewable Portfolio Standard.

Denmark and Germany were thus chosen as the central subjects regarding the successful implementation of policy to both increase the use of wind energy and to

develop and sustain a wind turbine manufacturing industry deriving from that increase.

The most significant change in the wind energy industry that has come to light since the onset of this research process has been the emergence of both a Spanish market and a Spanish industry. The nature of this emergence was rapid and, it is suggested, is of direct relevance to the question as to whether it remains possible to successfully enter the wind turbine manufacturing sector (Connor 2000). Thus, an analysis of the development of Spanish wind power was introduced. Analysis of the nature of the growth in the scale of the Spanish wind turbine market, and of the manufacturing industry servicing that sector, was also carried out. It is suggested that the Spanish industry has a direct relevance to the level of opportunity available in the global marketplace for new entrants.

Additionally, part of the research process included the decision to try to apply a typological theory for entrepreneurial success, as proposed by Low and Abrahamson, regarding the behaviour and survival attributes for new entrants to an industry (Low and Abrahamson 1997). The decision to apply this theory stemmed from the observation of a close fit between the theory and the pattern for the growth of the Danish turbine manufacturing industry up to 1990, as described by Karnøe (Karnøe 1990).

It is suggested that numerous events since 1990, and particularly the progression of the industry in Spain, provide evidence for the applicability of this model and also provide a more complex justification for the possibility for entry than is apparent from a *prima facie* interpretation of the Spanish sector only.

## 2.4 Methodology

Initially, it was decided that the main body of the research would centre on personal interviews carried out with a range of actors within the industries of the UK, Denmark and Germany. Subjects were chosen to include manufacturers, trade representatives and project developers. Unfortunately, lack of availability of funds meant that it was not possible to spend significant time overseas. Happily, this coincided with a change in direction of the work, and the splitting of the research into the two sections. Firstly, the consideration of whether there is still opportunity for the UK to develop a wind turbine manufacturing industry, and secondly, the consideration of the transferability of successful policy on RET industries between different technologies and countries. Twelve interviews were carried out on a formal basis, and in the region of fifty conversations on a less formal, face-to-face basis. Informal discussion has also continued to take place with some subjects via telephone and electronic communication

It was decided to carry out the research in the form of national case studies in order to form an assessment of the whole picture of the countries chosen as important actors in the wind energy field. The use of the case studies would also highlight the range of different factors affecting industrial policy and development, which it was felt would provide more insight than would be the case if alternatives such as a statistical methodology were employed. Further to this, it was felt that insufficient statistics were likely to be available with regard to the UK, due to the general failure in developing RET there, and possibly with regard to Spain, due to the recent nature of the emergence of the Spanish industry.

With regard to the first area of consideration – the availability of opportunity for new companies to access the market – the publication of a generic model for the

assessment of entrepreneurial success with regard to industrial context (Low and MacMillan 1988) gave a basis for a new analysis of the development of the wind turbine manufacturing industry. This led to an increasing emphasis on demonstrating an historical fit between the model and the reality. This would be achieved through a greater emphasis on analysis of information already publicly available with a much-reduced emphasis on original material.

The second part of the research assesses the applicability of various policies to countries other than those in which they have already been applied. Most specifically in this case, the UK, with the point of view of the possibilities for developing a market and via this, an industry. Whilst much of the information is drawn from conversation with actors within the wind industry, considerable emphasis also had to be placed on the application of information already in the public domain. What is hopefully noteworthy is the focus of the analysis. This emphasises the actions of relevant sector actors, particularly government, with regard to the creation of industrial and economic advantage for those companies originating from their respective home countries, with the aim of securing the corresponding economic and social gains for their constituents.

Considerable emphasis is placed on the subtext of policies, that is, the ramifications of a policy which go beyond its stated intention. The primary example of this would be with regard to the possibilities of directing the operation of a particular policy such that it gives preferential support to the industry of the policy initiator. Such protectionist aims, and the potential for the adoption of policy which enable them, will form the main components of the discussion as to the transferability of policy from one nation to another and to the applicability of policy to both industrial and market growth. To this end, the work takes in a significant cross-

disciplinary swathe, and analysis includes consideration of policy relating to economics, the environment, technology, innovation and energy.

Analysis also includes a consideration of the stated commitments of many governments to the promotion of RET as a basis for development of new industry. It endeavours to explore how environmentally-motivated actors might exploit this to increase the rapidity of growth in relevant sectors.

The discussion of this possibility forms another original aspect of the work. It is proposed that the actions of environmental groups drives political pressure to improve environmental conditions and that political actors can then act to use that pressure as leverage to introduce policies relating to the environment which also have the effect of creating non-tariff based barriers to trade which can be justified due to their environmental benefits. This is what Steven Vogel refers to as ‘regulatory subsidy’ (Vogel 1997). Whilst this principle as suggested is a general one, and will be described as such within this work in order to both clarify and justify it, it will also be considered with regard to its potential application to defending national interests relating to RET industries and to wind turbine manufacturing specifically.

## 2.5 Practical Aspects of the Research

The first practical consideration of the research concerned the availability of information. The documentation which can usefully be considered has been restricted by the language skills of the researcher to English. Documentary material pertaining to the UK has been reasonably easy to access, and naturally has always been in English. Material concerning Denmark seems to be translated almost as a matter of course, a policy which seems to have applied for what is now a quite reasonable period. As a result there is now considerable information available concerning



Danish policy, industry and development. This has further been bolstered through publication of information using the internet by many relevant Danish actors.

German documents seem to be translated into English with much less frequency, though the general feeling of the researcher has been that information has been generally been available when required.

More problems existed with regard to accessing information on the development of wind power in Spain. The increase in the use of wind energy has been of such rapidity that there is very little documentation available as yet, and of what is available, even less is available in English. Thus the large majority of information used here has had to be garnered from secondary sources, often sources which are based outside Spain itself.

The most notable absences from the literature, both from governmental sources and from trade representatives, naturally relate to the role of some policies which might engender advantage to parts of the industrial sector in particular countries. Naturally, such information is not promulgated in an obvious manner at any level, and even where it might only be alluded too, it is to be expected that this might not be included in translated material.

It is worthy of notice that information and statistics regarding the state of an industry, the policy that applies, and the capacity that has been installed, does not become publicly available with the same rapidity for all states, thus some parts of this research will utilise material that is more up to date than is the case in other sections.

## 2.6 Interviews

Subjects for interview were initially approached by telephone, offered a brief introduction to the author and description of what the research process was hoping to achieve. They were then queried as to their willingness to undertake an interview.

The responses were variable, ranging from those respondents who were very keen to discuss their roles, through to those who refused to consider the possibility.

Where the subject was agreeable, interviews were generally carried out in their place of work. Interviews were recorded when the subject was agreeable. In some instances the interview was carried out on an off-the-record or informal basis at the request of the subject, and naturally their wishes were respected. Hence a considerable amount of information was collected which can not be attributed but which provided greater direction to the research.

In a number of instances, subjects amenable to recording added further comments after the main part of the interview was over and recording had ceased. In the opinion of the author, this stemmed from a wish to provide information or personal opinion held in professional or commercial confidence, or which they did not wish to later have represented against them, or which might show them not to be in full agreement with the publicly stated policy of their employers.

Further information was also gathered with actors in the field on an informal basis through conversation at conferences and public meetings.

## 2.7 Problems

Clearly, not having the full availability of subjects acted to limit the scope of the work and may have acted to alter its overall direction. The changing nature of the focus of the research during the research period, however, means that this has not proven to be an insurmountable problem, though it initially presented some issues with regard to focussing the thesis down to a final conclusion.

The problem of gaining access to all information has been discussed above. As has been made clear, a large amount of the information gathering process is limited by confidentiality. Clearly, in some instances once one has been made aware

of particular issues arising from such material, it is possible to search for alternative sources of information which allow issues raised to be discussed. It should be noted though that it is not always possible to obtain alternative corroboration, and thus it is not always possible to investigate all aspects of statements made by some subjects. Naturally, the primary concern in investigating issues arising from confidential communication is to ensure that confidentiality is maintained.

The nature of any interview is such that it is not possible to be sure as to what extent answers reflect the absolute truth, the truth merely as the subject perceives it with the possibility of misunderstandings on the part of the subject, is partially truthful or is untrue to some degree. Naturally the burden of judging the accuracy of any statement and verifying the degree of objective truthfulness lies with the interviewer and each statement made by a subject must be judged within the context of other information available and by cross-referencing with material from other sources.

Motivations in the setting of policy, or of the actions taken, or not taken, within the context of that policy, are always open to interpretation, but sufficient weight of evidence is presented regarding the different policy strands that as a whole a coherent direction can be shown.

Finally, in terms of the finished piece of work itself, it must be borne in mind that the completion of this work occurs over a significant period of time. The constantly changing nature of the renewable energy industries, and of the different national policies that relate to how the markets are stimulated means that it is not possible to keep up with all the changes to policy that have occurred during the writing-up period. Every effort has been made to include any significant policy changes that have occurred during this period, or to detail any repercussions of new

policy that have become apparent. Inevitably however, cut-off dates have had to be applied with regard to what could, and could not, be included in the final submission. These vary to some degree with regard to each of the countries detailed in the case studies. The Spanish case study covers policy developments up to early 2001, the German and Danish case studies up to mid-2001, and the UK case study up to the publication of the UK Government's 'Renewables Obligation Statutory Consultation' document on August 3<sup>rd</sup> 2001.

### Main Points of Chapter Two

- The main aims of the thesis were recognised to be assessment of remaining opportunity for accessing the wind turbine manufacturing industry, the potential for the UK to develop such an industry, and the lessons that could be learned from policy regarding the industrial development of the wind energy sector.
- A methodology based on case studies was chosen in order to qualitatively assess the various aspects of industrial policy relevant to national success in the sector.
- Denmark, Germany, Spain and the UK were chosen as case studies to represent national wind turbine industries at various stages of advancement, and as these were best suited for research purposes.
- A typological theory of entrepreneurial success devised by Low and Abrahamson (Low and Abrahamson 1997) was chosen for application to the wind turbine manufacturing industry after being identified as closely fitting the early development of the industry as described by Karnøe (Karnøe 1990).

## **Chapter Three: Development and Protection of Industry**

### **3.1 Introduction**

This chapter addresses the general methods that are open to nations through which they can protect or enable the development and expansion of particular industries. All of these will be discussed with particular reference to the countries chosen as case studies in the relevant chapters but can be best described in a more general sense first.

Porter suggests that the government role should be that of catalyst, creating the conditions necessary for industrial innovation, and as a challenger to increase the aspirational range of its companies. He presents eight points outlining the approach he believes Government should take with regard to advancing the international competitiveness of a nations manufacturing industries (Porter 1990d). Merchant (Merchant 1997) narrows this to six points, as follows;

1) stimulate demand for innovative new products;

for example through tax credits on purchases for advanced equipment which Merchant states have been shown to act as a stimulus to innovation in certain industries

2) Co-operation between industry and universities;

Porter suggests that the core of R&D should be focused at universities and that increased co-operation between companies and these institutions is necessary to allow the companies to increase the level of integration of new technology. This is discussed at greater length below.

3) Enforcement of strict standards;

these have been shown to stimulate improvement in the domestic market and increase competitiveness.

4) Tax incentives for long term capital gains;

Porter suggests this is the most powerful way of increasing the rate of sustained investment in industry.

5) Enforce strong antitrust policies;

again with an action aimed at stimulating competition in the domestic market which should lead to increased competitiveness at the level of the international market

6) Reject managed trade;

such management acts to allow companies to remain inefficient and fail to achieve greater competitiveness, both Porter and Merchant suggest.

It is generally accepted that one of the primary functions of government is to foster economic and social gain through the encouragement of industry. To this end, countries, through their governments, employ a wide range of policies, some designed to encourage trade and industry as a whole, some designed specifically to maximise advantage to their constituents.

An increasing emphasis on international free trade has meant a greater pressure on most nations to remove many of the advantages they might have previously provided. Multilateral agreements such as the GATT act to limit what policies countries may initiate to enhance their own industries at the expense of their competitors. Many avenues for protecting and supporting both nascent and

established sectors remain in existence however. These can be split into four main groups, which are described in very simple terms below;

1) Those which are generally accepted as being a function of government, the primary examples being provision of R&D funding and of education.

2) Those which would be legally unacceptable but which are unlikely to lead to complaint for political reasons; generally to avoid retaliatory complaints.

3) Those yet to be legally judged as unacceptable, including those to which it is difficult to apply legal obligations.

4) Those which may be illegal within the constraints of international trade legislation but which are initiated to gain advantage whilst usually slow legal processes are brought into effect by the relevant bodies.

Vogel (Vogel 1997) questions whether nations actively compete to remove regulation as a way of driving down costs, or whether they compete to introduce regulatory subsidisation. The conclusions drawn are that there has been no overall trend internationally, and that governments tend to act in the interests of specific groups which are different for each nation, and that this difference is sufficient to ensure that national regulatory strategies are different. Vogel's work is important to this research for two reasons. Firstly, because it allows the conclusion that there are multiple winning regulatory strategies rather than just one, and secondly as it acknowledges the role and importance of international competition in the setting of national regulation.

The developing and rapidly expanding nature of renewable energy technology manufacturing industries, and the projected potential scale of the markets for these technologies, has meant an increasing interest on the part of national and regional governments, and this has led to the application of policies falling into each of the categories described above.

This chapter will describe, in general terms, the range of policy options available with regard to aiding the development of industries within countries. Where appropriate it will provide examples showing the actual effects of a policy in place. These will largely be examples related to the development of renewable energy industry, though these will be described specifically and in greater depth in the various national policy profiles that follow in later chapters.

### 3.2 Support vs. Protection

Fundamentally, governments will always act to advantage companies which benefit their constituents. These benefits accrue in a number of different ways. Domestic companies, trading at home, will provide jobs, stimulate the economy and provide profit for shareholders, which is most likely to be re-invested within the country then otherwise. If trading overseas they will also benefit the balance of payments, increasing profits and, if production continues to be domestically based, jobs available at home.

Foreign companies trading domestically act to draw funds away from their host countries economy and negatively effect the balance of payments. However, they are likely to act to increase employment opportunities, either through direct employment or through stimulation of support industries, wherever they are situated.



Companies acting outside their home market often also act as a conduit for the transfer of technology and technological skills. Whilst governments might prefer to have their domestic industry servicing a market, where this is judged to be difficult to achieve, or the government does not wish to attempt to try, they will frequently provide policy to encourage foreign companies in order to take advantage these social and secondary economic gains. The Rover car group, purchased from its British owner by the German BMW group, and supplied with financial support by the UK Government in the late 1990's exemplifies such a situation. (Brady and Lorenz 2001)

Obviously there are generally a large amount of projects competing for funding. There has been a considerable discussion of how Government should choose which technologies to support, or if it should try to choose at all, given the poor track records of many in selecting 'winning' technologies. (Porter 1990e; Porter 1990a; Porter 1990d; Merchant 1997)

Governments will have certain criteria for deciding which technologies to support, what level of support is given and when to terminate that support in favour of other technologies, and that these criteria will vary widely with regard to a long list of conditions.

### 3.3 The Role of Regulation in Innovation Policy

While Yeager's definition of general technology innovation as the most important factor for growth may be arguable, nevertheless such a role for innovation can, at a minimum, be regarded as of high significance. In the same journal, Koch (Koch 1998) emphasises the need for continual improvement of government in driving innovation in the energy sector, even in liberalised and deregulated markets, with this involvement balanced against the play of free market forces. Koch's

arguments in favour of intervention are again based on the need for establishment of long term policy goals which, he suggests, are badly supported by the private sector. He points out that such intervention is of particular need in the energy sector, on the basis that this sector is essential to industry, and hence is key to economic growth. Alongside energy security and environmental sustainability, Koch identifies this as being both essentially a long term goal and as necessitating development and deployment of new energy technologies. Koch points out the large time lag between carrying out research and that research translating into useful new technology. Koch further suggests that the present scale of new research being carried out is insufficient to maintain the rate of innovation in the future. Koch also suggests that governments should intervene to remove “market distortions that block the uptake of new technologies where appropriate” (Koch 1998).

The main problem with Koch’s suggestion however, concerns the question of too what degree this intervention should occur. This question, extended to the role of government as a whole, is, as Braun puts it (Braun 1994), the key dilemma of innovation policy. That is, the question of where regulation should begin – or whether it should begin at all – in order to protect health, the environment and so on, and the point at which it should end in order that it does not act to limit freedom, constrain the market excessively and slow the rate at which technological innovation and economic growth occurs. There has been considerable discussion of the issues concerning the limits of regulation, see for example the debate between Siegan and Galbraith (Siegan 1980), with arguments dependent not only on political ideology but on what is set as the aim to be achieved through government interference in the market. While Siegan might argue that the minimum amount of regulation is best for

the consumer on the grounds that it will always result in lower prices, Porter (Porter 1990b) begins from the perspective of improving national competitiveness and presents evidence to suggest that early introduction of higher standards in one country may act to improve that country's competitiveness when its companies attempt to operate in the international marketplace. Porter is thus suggesting that regulation may benefit the national interest. This will be addressed at greater length with regard to wind energy in later chapters.

It should be noted that Porter's assessment of the potential for increased regulation leading to greater competitiveness is the subject of a large degree of contention. Porter's hypothesis, as it is known, has been assessed from a number of viewpoints. It has been criticised by economists on the basis that economic theory suggests that companies should act to seize opportunities that already exist, and do not need to be triggered to do so by extra costs (Oates, Palmer et al. 1993; Xepapadeas and de Zeeuw 1999). Porter and van der Linde (Porter and van der Linde 1995), amongst others, have presented considerable evidence however, that companies are often triggered in this way, indeed such triggers are the basis for much of the theorising relating to the use of win-win situations in dealing with environmental impacts of economic agencies and actors. Economic theory suggests that introducing environmental regulation acts to increase prices and that companies subject to it will experience increased prices, rendering them less competitive and forcing them to relocate to territories with more lax regulation or to lose business to companies operating from those territories. To prevent this, it is predicted that territories compete to reduce the level of regulation. This is known as the 'Race-to-the-Bottom', and can be used, at least in part to justify the existence of regulation aimed at applying

minimum environmental standards. There is evidence that increased environmental regulation causes some industry to move overseas, though it is by no means definitive. The theory fails to take into account intangibles such as customer preference for non-economically measured factors such as environmental benefits, as well as economic benefits that may accrue from any new industries and opportunities created by increased regulation. Furthermore, there is considerable contention over the possibility that there may be the potential for a 'Race-to-the-Top' or 'Race-to-Strictness' (Vogel 1995; Swire 1996b). Vogel, using the term 'California Effect' to describe the phenomenon, posits the circumstances in which such an effect might come to pass. Necessary conditions include the existence of a large domestic consumer base which provide the leverage to enforce regulations on importers. This theory allows for public choice to play a part in the economic theory, though as Swire makes clear, it is limited in its application (Swire 1996a).

Braun delineates two effectively separate forms of regulation affecting technology policy, the first includes those measures which support the development of new technology, provide infrastructure and cater to the satisfaction of a public need, and the other kind which he identifies as a necessity. These are the regulations which act to safeguard health and safety and protect the environment and which he suggests without regulation would lead to considerable damage. The problem of course, lies with what different groups regard as necessity or not. Essentially this is the argument that arises between industry and environmentalists with regularity, though, according to the general interpretation of the Porter hypothesis, such regulation can actually be in the interest of both of these parties.

With respect to government support of technological innovation, Braun acknowledges the argument that as private enterprise benefits it should also bear the costs, but answers with the argument that the state “ought to try and support such technologies that are of obvious benefit to the public at large”. Braun concludes that no general rule can be stated, and that “there is no substitute for handling the support of new technology with sensitivity and good judgement”, a paraphrasing perhaps of Galbraith’s reference to distinguishing wise and unwise regulation (Siegan 1980).

The case of renewable energy technology, its development and implementation, provides a study for another argument about the desirability of regulation. In terms of the unregulated free market, the high economic costs of renewable energy technology means it is difficult for the technology to compete with the established – or conventional – fuel sources, and indeed it is further disadvantaged by the entrenched market positions of the already mature and established technologies. While renewable energy technologies have the obvious benefit of considerably lessened environmental impact when compared with the conventional fuel sources, the straightforward economic analysis of the fossil versus renewable fuel sources favours the conventional. Clearly however, reduced environmental damage is in the public interest, and thus increased regulation can be argued to be in the public good. Since the cost of much of the environmental damage resulting from fossil fuel power stations is not passed on to the customer but is instead borne by society in general in the form of general health problems, increased fatalities and damage to flora, fauna and buildings, it can be argued that the energy market is effectively distorted in favour of their use, and to the disadvantage of non-polluting energy sources anyway. Increasing regulation to acknowledge this subsidy could be regarded

as an attempt to remove this market distortion. Environmental campaigners have long promoted the inclusion of such externalities in the cost-benefit analyses, and the actual price, of fossil fuels. The concept of public funding for work that is in the public good, even where the some of the eventual benefits might accrue to private individuals is well established in economics, and appears to be justifiable if the perceived benefits to the public outweigh the costs.

Issues such as dealing with the advantage gained by the conventional fuels entrenched position are again a matter of ideology. While some might argue that advantages such as the structure of centralised generation and the historical preference for large-scale electricity production is an effect which the free market has found desirable and is therefore the best available, others might argue it is only as a result of political decision making and past regulation that the situation is as it is, and that previous legislation legitimises further regulation to attempt to obtain a ‘more desirable’ outcome.

### 3.4 Options for Developing and Protecting Industry

#### 3.4.1 Research and Development

R&D is generally regarded as being a primary function of Government, its funding is a fundamental aspect of a nation’s science and technology policy, and thus its innovation policy. Porter (Porter 1990c) emphasises the importance of correctly directed funding for this purpose. It is possible to direct funds in a ‘wasteful’ manner and such instances are well documented. As well as providing funding themselves, governments also act to try to stimulate greater R&D funding on the part of industry, frequently through the linking of private funding to government funding as a form of leverage.

R&D funding can be both a direct and an indirect subsidy. In the indirect form, such as in grants to universities and research institutes, it is particularly uncontentious. In the direct form, there is perhaps more room for it to draw criticism, should the subsidy extend so far as to present direct and obvious competitive advantage.

Presently, there is a definite trend towards a reduction in R&D provision amongst almost all the major economies; of the G7 nations, only Japan has not experienced a decline in its energy related R&D funding over the 15 years to 1998 (Yeager 1998). As Yeager also points out, this general reduction is despite the fact that the rate of return of investment in innovation is significantly higher than, for example, investment in plant and equipment. Yeager acknowledges improved efficiency in industrial R&D spending but suggests this leads to focus on the short term - a point which has been raised as an issue in a variety of forums - and is in agreement with the US Presidents Council on Science and Technology report of 1997. This states that if R&D funding, and thus progress, is not sufficient, “the future will be less prosperous economically, more affected environmentally, and more burdened with conflicts than most people expect”. Yeager quotes the work of Romer and Mansfield and their conclusions that all “fruitful research serves the public good”, that is, that the unpredictable nature of R&D and the unexpected results it produces means that both public and private R&D can lead to either or both public and private gain in a way which may not be predictable when research is initiated (Yeager 1998). He urges concentration on providing a framework for advancement of discovery rather than trying to legislate efforts on a pre-destined, and perhaps unattainable, focal point. He concludes that the “emphasis on short-term technology adaptation at the expense

of investment in technology innovation ignores the latter as the single most important asset for sustained economic growth” (Yeager 1998) and urges a greater collaboration between the private and public sectors to remediate the situation.

Public funding of R&D is frequently regarded as being essential to maintaining competitiveness of a nation in the long term, a burden which is not generally borne by the private sector, or at least not directly. It has been suggested that such public sector provision is a valuable part of Government’s efforts to reduce the levels of risk to private companies and to encourage the innovation process. Braun (Braun 1994) posits that in situations where an action has the potential to benefit society, either economically or in some other way, but where the risks attached are too large to be borne by a private enterprise, then “public bodies feel justified in taking measures to share, or even bear, the risk”. Thus, if a government believes that its industry is likely to benefit from new technology, it may support its development as one of a number of options for its introduction. R&D support is one of the least controversial methods of supporting the introduction of new technologies.

Jacobs suggests that the uncertainty inherent in R&D acts to justify its funding from public sources as ‘in the public good’ (Jacobs 1998).

#### 3.4.2 Education

Clearly there is some room for overlap of provision for education with provision of R&D funding, notably with regard to the support of research institutions and universities. However, Porter also emphasises the importance of investment in high quality educational resources, presenting evidence linking heavy educational investment to competitive advantages in a number of industries. Porter further suggests that “Education and training constitute perhaps the single greatest long-term



leverage point available to all levels of government in upgrading industry” (Porter 1990c pp628).

Provision of funding to education is regarded as support of infrastructure, and is thus generally beyond the scope of any trade agreement.

Porter (Porter 1990b; Porter 1990a) also presents evidence that what can be regarded as normal governmental provision of general education is of little help in providing any gain in terms of competitive advantage. Spending on education tailored to specific industry, specialised apprenticeships or university based research for example, does however bring a distinct advantage. Porter cites a number of examples where specialised educational facilities have been developed, often at the behest and with the financial support of industries themselves, to act as part of the self-sustaining support mechanism for nationally based industry to maintain advantage over its global rivals. A focus on education, for example, is regarded as one of the main reasons as to why Germany was able to overtake British industrial efforts at the end of the nineteenth century. British efforts, backed with a less cohesive educational structure – and often trying to follow Germany’s lead, though with less commitment – remain behind to the present day (Prais ; Hobsbawm 1968; Landes 1969; Freeman and Soete 1997). Freeman also underlines the importance of the roles of both R&D and technical education in the loss of British technological leadership to Germany and the US during the early years of the twentieth century (Freeman 1992).

### 3.4.3 Protectionism

It is possible to categorise policies encouraging the growth and development of an industry within a country following a large range of different bases. For the purposes of classification here, they will be divided into rough categories of policies

which are, or are not, protectionist in some form. It should be made clear that it is not always possible to clarify some policies as firmly in one camp or the other, and where this is the case, every effort will be made to comment as to the actual nature of the policy. These categories can then be broken down further, most notably to describe those policies with direct and indirect economic impacts.

There is considerable evidence that new markets and new industries often require assistance if they are to overcome the inertia of the marketplace, and this is also true of disruptive technologies such as wind and photovoltaic solar power (Baumol 1995). How this assistance is provided however, leads to considerable contention. The line between basic support and outright protectionism can be a fine one, and it is this that leads to confrontation between various actors at the international level regarding trade conflicts.

Protectionism itself has a fairly simple definition; it is the application of policy which provides advantage to a particular industrial sector with respect to its competitors. Normally such a policy would be initiated by one country to protect its companies against those of other nations, and to increase their comparative market share. Policies are classified as protectionist if they offer an advantage to one economic entity whilst withholding it from another or if they impose a burden on one, whilst exempting others.

In practice, there are two notable areas in which such policy might lead to conflict. Firstly, between actors in the same sector who are respectively inside and outside the domain of the policy, and secondly, between the advantaged sector and other industrial sectors. For example, one country might initiate policy which advantages its wind turbine manufacturing sector, this might lead overseas

competitors to seek legal redress to prevent the gaining of a trade advantage. It might also lead to complaints from other electrical plant manufacturers and fuel producers if an applied comparative financial advantage results in their technology losing market share to the competing technology.

### 3.5 Pitfalls of Protectionism

In purely economic terms, protectionism of any kind is held to be deleterious to the efficiency of free markets and wasteful of resources, and thus not in the interests of consumers. Sykes (Sykes 1999) outlines the bases of both traditional fiscal protective measures such as subsidies, tariffs and quotas, as well as considering what he terms 'regulatory protectionism'.

The attraction of direct subsidies are obvious. They enable the domestic industries of a country to gain a head-start by developing a base domestically, or allow access to a domestic market already dominated by overseas interests. Either way, the temptation is to try to gain access to the market in order to secure the increased employment and other economic benefits that can accrue.

Cable (Cable 1983) advocates a case for resisting the temptation. Firstly, he suggests that introducing protectionist policies leads to, directly or indirectly, a 'beggar my neighbour' affect, that is, the introduction of similar policies by competing nations, which, as the capacity exceeds the market, leads to insufficient sales to maintain the market, which leads to a return to unemployment. Cable thus concludes that protectionism is essentially self-defeating. He also suggests the possibility that protectionism can further be damaging to a country economically, as it acts to lock in scarce skills to low productivity activities.

Cable's conclusions however may not take into all of the relevant factors into consideration, or to consider the full range of circumstances. Is it possible that not all circumstances are so straightforward as is assumed? Could for example, legislating to provide protection in the early stages of an industry's growth help by providing skilled and experienced workers which can be the essential factor in moving the industry forward to an unprotected competitive stage? Essentially, can it be assumed that retaliation will always be engendered, and might there be circumstances where it is ignored? Porter presents significant evidence that any protectionist policy is essentially damaging to the competitiveness of a country's industry but again there would seem to be cases, and these will include RET's as will hopefully be demonstrated in later parts of this work, where such policies can act as a seed for the growth of an industry from the cottage level to an international level.

While undoubtedly there is considerable truth in Porters theories, they do not seem to take into account the extent of the societal barriers that can act to prevent the expansion of new technology, and do not perhaps address all of the factors which make new technologies attractive. In simple terms, one example might be of any technology or industry which is created which serves a public need which goes beyond the simple economic interest. Where Porter addresses the issue of the environment (Porter 1990d), he suggests the cause of its protection is a positive in terms of the possibility that the setting of higher standards may lead to increased competitiveness and increased opportunities for business, though this is perhaps one of the most controversial of the conclusions drawn in Porter's work. This perhaps returns us to the dilemma regarding the application of regulation which was raised earlier. Legislation regarding the use of environmental standards will frequently be

restrictive if it demands the use of certain levels of RET's, for example. In purely economic terms, their use will be at the expense of businesses supplying energy from other fuel sources, and of all the secondary industries associated with them. While this may lead to a greater competitiveness in those industries for the business which is available; those who fail will effectively be doing so to a protected part of the power industry. Political considerations however, make applying such policy desirable in a number of circumstances, as do non-economic factors such as those relating to the public good. The benefits of encouraging new industry in one's own country, at the expense of the market for the goods of another nations companies, are obvious, and provide a primary example of one such set of circumstances, though there remain arguments about the rights of the consumer to access the cheapest possible goods and services, which such a policy effectively blocks.

An example of one of the problems stemming from regulation, is in terms of the setting of standards which can often be apparent as promoting products. Whether or not the protection is backed with funding is not necessarily relevant. Encouragement of the more expensive wind technology, for example, at the cost of reduced markets for coal generated electricity, while perhaps improving competitiveness within both industries, effectively allows the wind technology industry not to have to be as competitive as the industry related to coal.

The essential question then, is to what extent such regulation should be applied, if at all.

### 3.6 Regulatory Protectionism

A significant part of the analyses of different national renewable energy policies addresses the question of regulation, particularly with regard to the potential

for RET manufacturing industry moving completely out from beneath the aegis of both fiscal and regulatory protection, and competing on purely economic terms, or at least to the extent that such a condition can be said to exist.

Regulatory protectionism is defined by Sykes as “any cost disadvantage imposed on foreign firms by a regulatory policy that discriminates against them or otherwise disadvantages them in a manner that is unnecessary to the attainment of some genuine, non-protectionist regulatory objective”. This is clarified as stemming either from the imposition of “substantive regulatory requirements” or from the “mechanisms used by regulators to ensure compliance with substantive requirements” (Sykes 1999). Sykes points out that the placing of such regulatory requirements is not necessarily intentional and can arise simply from a poor appreciation of the effects of policies.

Sykes suggests that while traditional protectionist methods affect welfare, and cause dead-weight losses to the Government and the people upon whom it places taxes, they do have returns in terms of the profitability of industry and employment as a result of the Government's shifting of surpluses. Their most negative aspect is that they draw funds away from areas which would, according to free market theory, have benefited more from the investment. Regulatory protection measures however, act to reduce the level of the surplus - that is, they effectively remove the potential for profit for some actors, to a degree that is not matched even with outright financial protections such as tariffs. This is achieved by moving the surplus that would have made up that profit to finance the imposition of the regulation (Sykes 1999).

As the scope of trade organisations such as the World Trade Organisation and the European Union has increased, and states have found greater limitations on the

fiscal protective measures they may place without direct retaliation, or without falling foul of penalties or fines, regulatory protection has come into heavier usage.

Naturally, as usage has increased, trade agreements have also addressed such protectionist policy. Sykes outlines the legal principles that apply in such cases quite thoroughly. The nature and wide variety of such measures however, along with the range of motivations for introducing them, are such that it is not always possible to remove or prevent their application. Additionally, the process of responding to the imposition of such regulation may be a slow one, particularly where the effects may not be obvious until it has come into place. An advantage may thus be gained whilst the force of the trade authorities are brought to bear. Furthermore, in the same way that tariffs, quotas and subsidies are not rendered illegal by trade agreements, they are merely restricted, not all regulatory protection is prohibited. Moreover, some aspects of regulatory protection are effectively outside the scope of trade agreements. For example, in those cases wherein national environmental or safety standards might outstrip those in force generally, then some competitive advantage may accrue on the basis that non-domestic competitors may not gain the same economies of scale that are apparent for domestic operators. It is possible that the high testing standards for turbine blades in Denmark may exemplify such a policy in action. (Krohn 1999)

Naturally, established industries will also perceive advantage in having both fiscal and regulatory measures put in place to protect them, and will lobby to achieve this. Generally, they will enjoy the benefit of being able to bring their greater resources to bear. Evidence from the United States shows that it is possible for industrial sectors to obtain beneficial trade circumstances through political funding in that jurisdiction (Baldwin and Magee 1998). Magee *et al* suggest that there is a very

good case for protecting both infant and ageing – what Magee terms senile – industrial sectors (Magee, Brock et al. 1986).

If a regulation applies to all companies in a market then it would generally not be defined as protectionist in nature, though there have been a number of cases recorded where regulations were introduced which were clearly designed to minimise impact upon the competitiveness of domestic industries as compared with non-domestic competitors. This has led to a number of legal challenges, some of which have been upheld, on the grounds that the stated goals of the regulation could have been achieved through less restrictive practices (WTO 2000c; WTO 2000b).

There seems to be general agreement in the literature that some competitive advantage may accrue to domestic companies on the basis that non-domestic competitors are unlikely to gain the same economies of scale that are apparent for domestic operators, particularly where domestic operators are already established and where regulation plays to the strengths of those operators.

Despite the economic pitfalls of protecting one's industry at the expense of one's competitors, it can be necessary to introduce such policy in terms of overcoming the advantages of already established entities and may be practicably essential if a nation decides it wants to develop an industry from scratch in the face of competitor nations already established in that sector. It is further necessitated if those competitors are themselves acting to protect their own interested operators. Baumol (Baumol 1995) suggests that in the case of environmental industries, including renewables, there is evidence that industries kick-started in this way are more likely to be retainable, that is they are less likely to move elsewhere due to the high start-up costs associated with them. Baumol also suggests that these high start up costs deter



initial private interest, and that it is in the public interest to meet these costs in order to stimulate the eventual growth of such a retainable industry. Georg *et al* (Georg, Ropke et al. 1992) suggest that “subsidisation is not seen as an effective instrument in environmental politics, but this conclusion rests on the assumption that subsidies are designed as negative taxes, connecting the subsidy to some reduction of emissions. However, subsidisation integrated in a technological development program is a very different instrument, effecting the development of clean technology in ways which are different to quantify, and thereby limiting the possibilities for a more formalized treatment”. They argue that in specific circumstances, subsidies can effectively stimulate clean technologies. Georg *et al* suggest that they are likely to be more appropriate in an industry based around Small and Medium Enterprises (SME’s) rather than larger, multinational companies (MNC’s). Subsidies effectively allow government to form a bridge with the SME’s that compose the industry in order to carry out R&D which MNC’s would typically do independently in industries in which they are involved. This point is likely to be of particular relevance in a comparison of renewable energy technologies, and in judging the applicability for the transfer of successful policies from one technology to another.

### 3.7 Financial Trade Barriers

Essentially there are three forms of financial trade barrier; tariffs, quotas and subsidies.

#### 3.7.1 Subsidy

Direct subsidy is one of the most basic forms of aiding an industry. It can be provided in a number of forms, not all of which are internationally approved. Witness

the WTO's recent ruling that subsidy of the production of aircraft for export from Brazil was against trade rules following a complaint from Canada. It is notable however that the subsidy was not illegal in principle, only in that it reduced financing rates below the international level (Williams and Dyer 2000).

Subsidies are prevalent in the energy sector. Germany has consistently provided billions of Deutsche Marks on an annual basis to underwrite its coal mining sector, justifying its expenditure on the grounds of national security of energy supply (FT 1994; FT 1995). The UK has recently reversed its policy regarding subsidy of coal with the provision of £100Million (Shrimpsley 2000), subject to approval by the European Commission.

Clearly subsidies of this kind act to deform the market. In Germany, for example, the policy acts to guarantee a market for the coal produced from the subsidised pits. This effectively hands coal production an unassailable market share, and acts to place an artificial limitation on the potential expansion of other energy sources.

There are a number of important differences between the coal industry and the industries relating to other conventional energy sources in a comparison with renewable energy technology manufacturers and generators. Clearly, RET production is not yet at the mature phase, thus the industry does not, as yet, produce the level of social and economic benefits that can be associated with established technologies - it can only offer the potential to do so. The established technologies thus offer a safer bet for some kind of return on the provision of a subsidy, albeit if it is only in the form of political capital through the continued availability of employment.

There are a variety of options for the provision of industrial subsidies. This term includes a wide array of measures, and could be said to include R&D funding in addition to “grants, loans, tax allowances and other incentives” (Cable 1983).

To give a simple outline of how such measures work;

- grants: generally provided through a structure which enables customers to purchase goods more cheaply
- loans: provided along with low interest rates to customers making the goods more economically attractive
- tax allowances : allow companies to write off purchases against their overall tax payments, effectively enabling them to buy the goods more cheaply or at least at a time which is more advantageous to the customer.

While these are the primary applications of subsidy, Brack *et al* list a range of other possibilities (Brack, Grubb et al. 2000 pp90), and also point out that whilst some subsidies to the energy sector benefit the environment, the vast majority act to increase the use of fossil fuels. The WTO (WTO 1998) lists a range of mechanisms which have these ends.

All of these subsidies effectively use government funding, either through direct payments or by avoided payments from the industry to government. All subsidies can be directed such that they benefit favoured companies, typically nationally based ones to the detriment of their international competitors in the domestic market, though they can be openly available to all comers if this is desired. It is important to note that whilst a policy may make some form of subsidy available

to all actors in a particular industrial sector, effectively creating an open market for a product, rather than being aimed at generating industrial opportunity for specific actors, the policy may also be reducing the size of the market available to another industrial sector. Clearly if the policy initiator wishes to favour manufacturers in the new industrial sector, then this form of policy can also be directed such that it can be regarded as being protectionist in nature.

The three major systems used for stimulating the increased use of renewable energy may all be regarded as a form of subsidy which acts to take away market share from other sections of the energy industry. In simple terms, these three systems are;

- **Renewable Energy Feed-In Tariff (REFIT) :** Wherein consumers/suppliers are obliged to pay a fixed premium sum for any renewably generated energy (or just electricity) they are offered. Effectively, government regulation compels consumers to subsidise renewable energy generation, usually through the suppliers.
- **Non-Fossil Fuel Obligation (NFFO) :** Wherein government offers contracts for fixed amounts of renewable energy generation capacity on a competitive basis to minimise costs, and these costs are passed on to the consumers through the suppliers.
- **Renewable Portfolio Standard (RPS) :** Wherein government compels all consumers to purchase a fixed amount of renewable generated energy, through their supplier, with the consumer/supplier able to choose the source of their energy, and thus purchase from the cheapest available.

A further subsidy can be provided in the form of government purchasing of goods, for example, Cable (Cable 1983), points out that in the UK, public sector purchases accounted for “12.8% of the value of production of manufacturing industry, the proportion exceeding 50% for a range of industries”. The increasing political importance of environmental issues has also brought the opportunity for governments to legislate for increased uptake of certain goods by both public and private institutions. Examples of this behaviour include legislation in the UK compelling electricity generators to reduce sulphur emissions leading to enforced purchase of flue gas desulphurisation equipment, though this was ostensibly to bring Britain into line with a European directive regarding reduction of emissions. Specifically relating to renewable energy technologies, in late 1985 the Danish Government legislated to oblige the two Danish utility companies to develop 100MW of wind energy technology capacity within five years and provided no financial subsidy to aid this increase. Almost certainly this measure helped to maintain the Danish wind industry through a period of international market weakness (Karnøe 1990).

International co-operation has led to the placing of some limits on the volume of goods that can be purchased from particular sources as part of government procurement, and attempts to regulate the awarding of contracts by government (WTO 1999).

### 3.7.2 Tariffs and Quotas

A tariff places a financial penalty on competitors goods or services in order to advantage the competitive position of domestic industry. Quotas impose a limit on the amount of a good that may be imported. As outlined above, the economic standpoint is that this inevitably leads to retaliatory action by the country which has

its industry negatively affected. The basic result is a drop in the overall efficiency of the market.

The potential for the application of such devices has been much reduced through the agreement of a range of treaties with the express intent of doing so, including those within the GATT/WTO, such as the Technical Barriers to Trade Agreement (TBT) which came out of the Uruguay Round (WTO 1994). This has led directly to a search for alternative methodologies for invoking barriers to competitors to secure advantages for domestic industries.

### 3.7.3 Dumping

A further policy which has the potential to act against the interests of the consumer in international trade is the use of dumping. Effectively, this involves exporting goods into another market at a price which is below the 'normal value of the goods', with the normal value generally defined as the 'domestic price of the goods in the country of export'. The aim of the policy is to provide the goods at a price which can not be matched by the domestic actors with the result that they go out of business and the importer can then raise the prices in a less competitive market and, in theory, recoup, their losses. International trade agreements do not utterly condemn dumping, notably as it is difficult to prove, and the WTO restrains itself from even condemning such action as an unfair trade practice (WTO 2001).

The nature of the WTO however, is such that it can take action on the anti-dumping measures which are the response of nations which feel that their industries are being disadvantaged by the dumping of importers. GATT (Article 6) does make a provision allowing countries to take measures to protect its industry from harm if they are subject to dumping, but makes clear that these measures are limited. Clear

evidence must be presented that the prices indicate dumping and that damage is being caused. Both agreements on dumping and on anti-dumping procedures have to be clear in order to prevent either from being abused to the protection of the industries of either of the interested parties.

Dumping tends to be used for larger scale businesses, and its effects on RET's would so far not seem to be an issue, though there may be potential for it to increasingly impact should markets continue to grow.

### 3.8 Non-tariff Barriers

The removal of many tariff based barriers to trade has resulted in increasing growth in non-tariff barriers, most especially to what Sykes refers to as regulatory protectionism. Sykes (Sykes 1999) defines this as

“any cost disadvantage imposed on foreign firms by a regulatory policy that discriminates against them or that otherwise disadvantages them in a manner that is unnecessary to the attainment of some genuine, non-protectionist regulatory objective. Regulatory protectionism can result either from substantive regulatory requirements or from the mechanisms used by regulators to ensure compliance with substantive requirements. It need not be deliberate and may result from regulators failure to appreciate the trade impact of their policies”

Sykes offers a number of examples of such policies, these including ‘facially neutral’ examples, wherein legislation outwardly imposes the same conditions but which actually have the effect of weighing more heavily on foreign competitors, either intentionally or through accident of circumstance. As a specific example Sykes describes the EU regulation which bans the use of growth hormones in beef cattle.

This regulation banned the use of growth hormones for all cattle to be sold in the EU, the burden however, is borne unduly by US beef producers as hormones are widely used there, whilst they are not used at all in the EU. US farmers wishing to sell in the EU must obtain certification that their beef is hormone free, thus acting to increase their costs and reduce their competitiveness (Runge 1998). This action, it must be noted, would be justified if it could be proven that the presence of hormones could be proven to be against the public interest. In the absence of any evidence for such a justification, the regulation can be seen to be protectionist in nature, or at least that is how it has been regarded following a judgement by the WTO (WTO 2000a). As other options for protectionist policy have been depleted, environmental considerations have increasingly being used to justify regulations relating to trade, and have provided an increasing number of further examples of this form of protectionism. Other examples relate to health and safety and to labour rights. A number of such examples will be detailed in greater length in the chapters specific to the application of policy to creation and development of the wind turbine manufacturing industry.

As a codicil to this, it is worth noting that such regulations can be justified if there is proof that they achieve a valid environmental goal. As a continuance of this, it is also worth noting that states may adopt tougher standards than those agreed internationally, or which are deemed acceptable by their competitors, in areas such as safety and environmental performance without breaking trade regulations provided they apply equally to all trading in the country where the policy applies and within certain other limits as agreed within GATT/WTO agreements, usually relating to whether the stated aims of the regulations can not be achieved more easily by other means. Notably even within these constraints it may be possible to gain advantage



through the imposition of high standards, Sykes (Sykes 1999) suggests that high standards acts to discourage foreign entrants to a national market sector due to the increased costs associated with the product changes necessary to enter the market and the reduced opportunities for economies of scale to which this leads.

Further examples of regulations with the potential, but not always the necessity, for protection, include the use of labelling, including eco-labelling, the imposition of safety legislation, requirements regarding the establishment of premises and even manufacturing capability within a country and the setting up of legal entities to make judgements regarding patent infringement by foreign competitors.

### 3.9 International Agreements Regarding Protectionism

The increasing level of internationalisation of trade in recent decades has also led to considerable expansion of multilateral international treaties curtailing what actions a government may employ to protect its industry. The most significant of these being the WTO, which superseded the General Agreement on Tariffs and Trade (GATT) in 1995.

WTO agreements diverge quite significantly with regard to their application to quotas, tariffs, subsidies and regulatory forms of protection. As Sykes notes (Sykes 1999), WTO agreements do not outlaw the use of tariffs, quotas or subsidies, they simply act to place a wide range of constraints on their use, some more so than others, and can apply penalties relating to the introduction of new controls. Quotas are particularly restricted, with any new use having to be justified as an exception within the terms of the GATT agreements, and compensation is often required for those whom the measures mitigate against.

New uses of subsidies are also quite heavily restricted. The WTO agreement on Subsidies and Countervailing Measures (SCM), which came about as a result of the Uruguay Round of GATT/WTO outlines what subsidies may and may not be applied, lays down legal definitions of such application and details a mechanism for dealing with reported infractions (Brack, Grubb et al. 2000). Brack *et al* also point out the considerable anecdotal evidence that exists in regard of the wide range of subsidies that do exist and which continue to be introduced which would, in all likelihood, be declared illegal within the purview of the WTO should a complaint be made concerning them. Brack *et al* suggest that complaints are not made for fear of attracting retaliation on the part of the complainant (Brack, Grubb et al. 2000).

It is suggested here that a further reason might exist to discourage complaints in some sectors. In circumstances where a subsidy exists to help develop a new industry in a country, the disadvantaged competitors from another, if they are capturing a certain fraction of an artificially created market, even where it is not as much as they would like, might be loathe to encourage a complaint on the grounds that this might cause the subsidy to be removed in its entirety, thus surrendering profitable opportunities for all. This idea will be expanded on further in the chapter concerning German efforts to encourage wind turbine use.

Sykes addresses the problems that the WTO has in responding to regulatory protection (Sykes 1999) and details the response they have initiated to deal with it. There are a number of major international agreements addressing the issue, primary amongst them are the WTO agreements on Technical Barriers to Trade (TBT) and on the Application of Sanitary and Phytosanitary Measures (SPS). The SPS agreement addresses issues relating to health, primarily with regard to food supply, and

concerning human, animal and plant life. The TBT agreement is intended to ensure 'that the use of technical regulations, product standards and conformity assessment procedures do not create unnecessary barriers to trade' (Brack, Grubb et al. 2000 pp51).

Brack *et al* also point out that 400-500 technical barriers are informed to the WTO annually under the WTO Agreement on Technical Barriers to Trade (TBT) and that none of these have yet been challenged as discriminatory, strengthening the argument regarding the effects of the fear of retaliation.

Sykes notes that these agreements embody six legal principles in attempting to realise their task;

1. The national treatment principle

Essentially forbids countries from applying conditions to the sale of imported goods which do not apply to domestic goods.

2. The sham principle and scientific evidence requirements

Attempts to address those regulations which are disingenuous in their motivation, imposing unfair restrictions under the guise of universally applicable regulation. This includes analysis of the potentially fallacious or disingenuous application of scientific principle relating to health to justify restrictions on access to markets.

3. Comment requirements and reference to international standards

Essentially deals with those aspects of regulatory protectionism arising through injudicious attention to their potential affects. The SPS and TBT agreements both call for regulators to publicise potential new regulation to

foreign operators and admit their comment and feedback. They also call upon countries to default their regulations to international standards to achieve an aim on the basis that these have usually undergone in-depth analysis prior to their implementation and can thus more easily avoid any conflict that a nation might independently arrive at without consideration of other nations operating procedures.

#### 4. Notice and publication requirements

These require countries to establish some form of institution allowing the easiest access to regulatory information.

#### 5. The least restrictive means requirement

Requires a country to choose the least restrictive method of achieving a policy goal, that is, to apply the most general form of regulation available. The principle also includes provision for one country accepting the standards of another where this achieves the goals aimed at in drafting the policy but does so in a less restrictive manner.

#### 6. Obligations relating to conformity assessment

Applies the above principles to the actual process of assessing conformity, that is, its basis is to act to ensure that the method for the application of, for example, standards, is not such that it imposes unnecessarily high costs.

Sykes gives the example of requiring testing at a particular laboratory when alternatives exist (Sykes 1999).

### 3.10 Protectionism and the European Union

As well as being WTO signatories, all fifteen EU member states have agreed to be bound by additional legislation applying to trade within the Union itself. Directorate-General IV of the European Commission oversees competition practices within the Union, and has made numerous rulings concerning the application of EU agreements on trade. It has the power to bring cases against potential offenders through the European Court of Justice should they fail to fulfil their obligations under European treaty. DG IV may also rule on certain issues affecting EU citizens as regards the fairness of imposed burdens, as was the case with the placement of limitations of the original setting of the Non-Fossil Fuel Obligation in the UK (Mitchell 1995).

The Directorate General can be quite slow to move however, preferring to provide warnings and notices of intent before actually moving to the stage of court proceedings. The proceedings then tend to operate at such a pace that a grace period of a number of years may exist. Thus any industrial support policy may be in operation for a number of years before it is eventually judged to be in contravention of community policy. This delay allows the provision of an advantage over what can be a considerable period before it is halted. It is also possible for a member state to come to an agreement with DG IV in instances where a case can be made that subsidies and other supports are in the economic, social or national security interests of the state involved.

### 3.11 Application of Protectionist Methods

There is a significant range of methods for applying the generalised models listed here, many of these are applicable to renewable energy technologies, and indeed, many may already have been utilised. Where appropriate, these will be described in much greater depth in the relevant chapters, along with commentary relating to the motivations for their emplacement.

#### Main Points of Chapter Three

- There are a variety of options available to nations wishing to stimulate the growth of a particular industry, some of these are more international acceptable than others.
- There are a range of mechanisms through which a nation may distort markets in favour of its own industry, including subsidies, tariffs, quotas, dumping and regulation.
- A number of international agreements exist to limit the effectiveness of these mechanisms. These agreements are not always effective however.

## **Chapter Four: The Development of the Danish Wind Turbine Industry**

### **4.1 Introduction**

Wind energy is undoubtedly the new renewable energy technology presently closest to achieving a place as a competitive large-scale generator of electricity. Equally, Denmark is undoubtedly the country that has enjoyed the greatest success in provision of equipment for its exploitation.

The origins, growth and development of the Danish wind turbine industry have been chronicled from a number of perspectives in varying degrees of depth in a range of other forums. Nevertheless the importance of Danish efforts in the field warrants the inclusion here of a detailed summary of previous work with the aim of providing context and a reference for the detailing of development outside the Danish experience. More importantly, perhaps, it will demonstrate the policies which buttressed its success. The chapter will also aim to update the analysis of the further development in the Danish situation.

### **4.2 Historical Use of Wind Energy in Denmark**

Though less famously than in the Netherlands, the use of windmills in Denmark was widespread throughout the 19<sup>th</sup> Century and actually expanded in the early decades of the 20<sup>th</sup> Century. Over 30,000 mills were in use up to the 1930's, many constructed as a response to fuels shortages resulting from the First World War (Jamison, Eyerman et al. 1990; Rasmussen and Oster 1990; Gipe 1995a; Tranaes 1997b; Tranaes 1997a). The first experiments in electricity generation from turbines appear to date from 1891 and Paul La Cour (Gipe 1995a; Tranaes 1997b). La Cour's efforts were commercialised and spread across the Danish countryside, with installation expanding through the first World War, declining between the wars and, alongside the efforts of F.L.Smidth, arousing interest again during the Second World

War as fuel problems again impinged on Danish life. During the war years wind turbines generated around 4GWh annually in Denmark (Rasmussen and Oster 1990). Rasmussen and Øster record that the primary motivator for La Cour's work was to facilitate rural electrification (Rasmussen and Oster 1990).

Construction during WWII was largely carried out by Lykkegaard Ltd and by F.L.Smith & Co. and their subsidiaries. Lykkegaard utilised La Cour's teaching, while Smith made a number of new designs, primarily aimed, at least in the opinion of Rasmussen *et al* (Rasmussen and Oster 1990), at progressing towards the capability for designing 'relatively large wind energy turbines suitable for supplying AC or DC electricity to minor electricity works and grid systems, as well as to large factories and farms'. By the end of the war, Smith was producing 24m bladed, 70kW generators with a range of innovative design characteristics.

Following the war, interest and installations again diminished. Development of the technology however was maintained through the work of Johannes Juul. Juul performed a range of experiments and considerably broadened the range of knowledge regarding turbine equipment, testing and performance, including the introduction of stall control technology. One of his most significant projects was probably the Gedser turbine, constructed in 1956 and with a generating capacity of 200kW. The turbine employed a number of innovative concepts and ran for eleven years without major maintenance before being dismantled in the late 1960's after it was judged that it required too expensive an overhaul. It was placed in storage and later used for data collection in a US-financed large turbine research programme. Gipe refers to the Gedser turbine as the "forerunner of all later Danish wind turbines" ((Gipe 1995a), pp54). Rasmussen describes Juul's design concept as 'a starting point and an inspiration for Danish designers and manufacturers'.



More general Danish interest was re-ignited with the first world oil crisis in 1973. At the time, Denmark was reliant for 92% of its total primary energy consumption on imports of oil. With the oil crisis threatening both the economy and the security of its energy supply, Denmark began to look for alternatives.

At this stage a number of new factors came into play. The Danish Government significantly increased provision of R&D funding as well as establishing other support structures for the growth of the market and industry. At the same time political influences provided a climate more amenable to the growing use of the technology. The existence of an industry and the knowledge embodied in this provided a base from which to advance the technology.

On the political side, one option strongly favoured by the Danish Government was nuclear power, though this was one of a number of measures that was taken under consideration alongside increased energy efficiency, increased energy taxation and a focus on improving the technology necessary to exploit the comparatively inaccessible North Sea oil and gas fields over which Denmark has sovereignty. The interest in nuclear power is important in the consideration of wind power due to the support given to wind power as a suggested alternative to proposed nuclear plans. However, in private conversation, one commentator suggested that the role of some grassroots organisations has been over-emphasised in some accounts of Danish turbine development.

Nuclear power had received previous consideration as early as 1962 by Danish industry and government, and the right to decide to construct a nuclear power station was awarded to the Minister of Education. In 1971, Elsam, one of the two Danish utility companies made a decision to express a formal interest in the construction of a nuclear facility and at the end of 1973 announced a list of potential sites for the

location of nuclear power stations. The following day, (Jamison, Eyerman et al. 1990) a new environmental organisation, the Organisationen til Oplysning om Atomkraft (Organisation for Information about Atomic Power) or OOA was formed from a group of people from three separate Danish grass roots organisations. It could essentially be regarded as an extension of the grass roots approach to issues that existed, and remains common, in Denmark. Grass roots involvement has meant Denmark has been at the forefront of environmental progress for some time, with significant actions often occurring at that level before they are taken up by politicians. However, take up of environmental policies at the political level is also comparatively rapid in Denmark. Danish groups have maintained a high level of political independence despite having many of their aims taken up as policy.

The rapidity with which the OOA was established meant that it had time to both gather a large amount of information regarding nuclear power, and to gain a significant membership, by the time ELSAM identified and announced it had chosen a site for its first proposed nuclear power station in 1974 (Jørgensen and Karnoe 1995). The OOA established contacts with political parties and the scientific research community and managed to install members on steering committees for public R&D programmes. They thus built the ability to influence the direction of the energy policy planning process.

As well as focussing on the potential environmental dangers generally associated with nuclear power and the campaigns against them, the OOA also objected to the 'centralising' effects of nuclear power, that is, the way in which the use of large-scale energy production techniques such as nuclear, as well as oil, gas and coal would lead to central planning and regulation, and thus to monopoly and

dependency. They also pointed out that the fuelstuff for nuclear, as with oil, coal and gas had to be imported and thus had a negative effect on the Danish economy.

The OOA further pointed out that the qualities inherent in renewable energy were such that all three of these problems could be avoided and thus proposed their much-increased usage as the solution to Denmark's energy problems.

Two years later, and 1975 saw a number of events which can, in hindsight, be regarded as important to the development of Danish wind power use, and to the creation of the turbine manufacturing industry. It was the year in which Christian Riisager constructed his first wind turbine, using a 30kW asynchronous generator. This was able to transmit, and thus sell, wind generated electricity onto the local grid system (Karnøe 1990). Riisager used a design similar to that used for the Gedser turbine and his company went on to build a further 50 similar turbines in the years 1976-1978 (Karnøe 1990; Madsen 1990; Tranaes 1997b), selling them to customers from a range of different backgrounds. His company however was not to survive the later influx in new Danish companies to wind turbine manufacturing.

The same year, 1975, also saw the beginning of the construction of the Tvind wind turbine. The Tvind school, where construction took place, was one of many Danish folk schools which provided courses and experimental activities many of which could be relevant to development of alternative technology. The turbine would not be finished until 1978, but even then would be the biggest wind turbine operating anywhere in the world, with a theoretical generation capacity of 2MW, though in reality never producing more than 1MW (Karnøe 1990). The turbine however acted as a '53 metre high argument' (Jamison, Eyerman et al. 1990) for the use of the technology, and as a focus for a range of people interested in developing renewable energy technology.

November of 1975 saw the establishment of another grass roots environmental movement, Organisationen til Vedvarende Energi (Organisation for Renewable Energy - OVE), its aims stated as dissemination of information with regard to the developing of renewable energy technologies. OVE focused their efforts on promoting the use of renewable energy, both through criticism of the Government's efforts in the field and, perhaps more importantly, through the actual practice of developing renewable energy projects. This enabled them to both demonstrate that such options were viable, and to build up a body of knowledge which could be passed on. OVE organised 'wind meetings' (Vindtraef) up to four times annually. Jørgensen and Karnøe (Jørgensen and Karnoe 1995), describe these as crucial "as a forum for the diffusion of knowledge, experience and new ideas". In contrast to the large Tvind turbine, most of the turbines being constructed at this time were considerably smaller, typically being 20kW-50kW generators.

The Tvind turbine was important for a number of reasons. Karnøe (Karnøe 1990) suggests it was an important symbol, most particularly of the 'bottom-up' approach, its construction being completed by a variety of interested volunteers, albeit several of them from related and appropriate engineering fields. It suggested the possibility of becoming involved in using the technology independently and encouraged others to get involved on this basis. The development of the turbine also had important implications in terms of the technology itself, particularly of note were advances made concerning the use of fibreglass blades (Madsen 1990).

Changes in blade technology were to provide another stimulus for the market. In 1977, sales of fibre blades separate from the rest of the turbine were made available. This was significant as it allowed those parties interested in wind power but lacking aerodynamics expertise easier access to the technology. Madsen

highlights the importance of the availability of the blades in enabling companies with no specialisations in aerodynamics to access the turbine marketplace. Madsen suggests that this was ‘the basis of a major industry...established, consisting of a design concept and established production capacity’. The same year also saw the introduction of a standardised relay-based electrical switching system which allowed electricity to be generated from wind to be passed to the grid, thus making the electricity a saleable commodity. These factors, alongside others necessary to the creation and growth of this industry will be dealt with in depth in the latter parts of this chapter.

Jørgensen and Karnøe estimate that by the end of 1977 (Jørgensen and Karnøe 1995) approximately 100 demonstration turbines had been constructed in Denmark. The primary effects of this were twofold. They acted as a working demonstration of the feasibility of the technology, and also, through the very fact of their construction, enabled a vast amount of knowledge and experience to be gleaned. Jørgensen and Karnøe (Jørgensen and Karnøe 1995) go as far as to suggest that without their purchase it would never have been possible to develop feasible wind turbines or the wind turbine manufacturing industry.

The nature of the development of the industry now began to change somewhat, becoming increasingly institutionalised. The year of 1978 saw the establishment of two more wind power related organisations. The first, the Association of Danish Wind Power Owners (Danske Vindkraftværker)(DV), was established with the stated aims of acting to initiate relevant research and to sort out legislation related to renewable energy (Tranaes 1997b). These remain as the goals of the organisation. The DV can basically be seen as a more formalised extension of the grass roots movement, its initial members were after all those who had personally

pioneered investment in the first wave of Denmark's modern wind movement. The role of the DV was an important one, it regularly published *Naturlig Energi*, a digest which passed on information regarding the performance of turbines. It thus acted to advise and protect new buyers and to force manufacturers to improve the performance standards of their apparatus or otherwise go out of business. These efforts to improve consumer knowledge of turbine performance occurred alongside the creation of the Test Station for Windmills which was established at Risø slightly later in the same year, and which tested any turbine that wanted access to the public funding which was made available from 1979. The test station, which was initially limited to smaller turbines, was funded from the Government's wind energy research programme, with DKKr5 million made available for its operation over the first three years.

The second organisation to be established in 1978 was the Danish Wind Turbine Manufacturers association (*Foreningen af Danske Vindmøllefabrikanter*) (FDV). Its aims to protect and work for the interests of the increasing number of small manufacturing companies which had appeared in what was still a high risk industry. Karnøe notes that a dozen new companies entered the industry in 1978-79 (Karnøe 1990). Many of the new companies entering the industry came not from companies specialising in aerodynamic applications, as might be expected, and which was the sector which formed the majority of those companies investing in wind energy technology in other countries. Instead, many were from agricultural engineering concerns which had spotted a potential market for the new technology amongst their regular customers. These new companies pushed out the smaller, older ones, such as Riisager's, and while many bankrupted and went out of business, those that survived now dominate the Danish and the world market. Grin and van de Graaf (Grin and van de Graaf 1996) suggest that those companies that survived did so as a

result of the application of superior management practices. Those that offered services linked to insurance, financing and production guarantees, and which better displayed “insights into international competition and domestic developments in their export markets”, were the ones to prosper. Grin *et al* describe the management paradigms of the early companies and the changes needed to survive as the market grew, both domestically and internationally. Applying the Low and Abrahamson model (Low and Abrahamson 1997) suggests that the changing conditions of the market also might have had an effect on the ability of companies to survive on entry to the industry. The changes detailed by Grin and van de Graaf, also tie in with the Low and Abrahamson model in terms of the need formal guarantee mechanisms more appropriate to growth phase survival, as will be detailed in chapter eight.

The role of the DV, along with the Risø test station was a significant one. Effectively, they established standards, one more formally than the other, and forced Danish manufacturers to improve the quality of their machines in order to have any chance of staying in business. While this may not have been welcomed at the time by industry actors, it is likely that as in a range of industries (Porter 1990b) (p.52), the long term effects was to make turbine equipment production more effective, and more efficient, than that of any external competitors to Denmark. The Danish turbine industry was thus provided with one of its greatest advantages in the global marketplace that was to develop in the following years.

For the setting of standards and the quality of products to have any meaning at this stage however, required the existence of a worthwhile market, and the essential first area for growth of an industry is the domestic market. The actions of the grass roots movement in developing and purchasing turbines had helped to demonstrate that a potential market existed and had attracted an increasing number of entrepreneurs

into the sector. Further the actions of the OOA, OVE and others had spread the message that wind existed as a viable energy source.

Whilst grass roots organisations undoubtedly had an impact on the development of turbine technology, a marketplace in which to sell it and thus on an industry to fill it, the Danish Government also played a highly significant role.

As well as heralding a new global oil crisis, 1979 also saw the establishment of the Danish Ministry of Energy (Øster and Jacobsen 1990), and the introduction of the first Danish Parliamentary Act to subsidise investment in wind energy technology, allowing a 30% subsidy of a buyers total investment in any turbine model approved by the test station.

The subsidy aimed, and succeeded, in further stimulating the demand side of the domestic market. This would later be balanced by a further Government funded programme, initiated in 1981-82, and run through the Ministry of Energy, to directly subsidise product development. This new Ministry involved itself in wind power technology, collaborating with a regional utility company to do so (Karnøe 1990). Their involvement acted to further increase the confidence of both investors and entrepreneurs seeking to enter the market. Prior to 1979, energy policy had largely derived from the Ministry of Commerce which had been responsible for policy relevant to the general development of energy technology. It is possible that market creation had yet to become regarded as relevant

This included the introduction, in 1976, of energy R&D programmes, including those for renewable energy technologies. Specific funding was applied to wind energy technology, with a general increasing trend towards 1982 at which point the level of funding was stabilised at a level at which it continued up to the late 1980's (Øster and Jacobsen 1990).



This R&D support manifested in a number of ways. It supported the Risø test station and a variety of research-led projects into a range of turbine designs and concepts, the first of which particularly would have long-term implications for the later development of the industry.

Writing in 1990, Øster suggests that projects up to that point were split into two rough groups. The first group, the Wind Power Programme, aimed to investigate the use of large scale turbines, and to ‘fit them into the Danish landscape as well as the Danish electrical network’ (Øster and Jacobsen 1990). The programme continued into the 1990’s (Grastrup and Nielsen 1990).

Whilst this research programme did not lead directly to the use of multi-megawatt machines, which instead have come about through a process of incremental growth, results from other aspects of its work have been applicable. For example, work carried out to establish technical criteria for integration of turbines into the national grid proved relevant.

The second group was concerned with the research carried out at Risø. By 1990, these were joined and all wind project proposals were judged by one research committee, the Research Association of Danish Electric Utilities.

#### 4.3 The Risø Test Station

The test station at Risø has already been mentioned more than once in this chapter, it is thus sensible to give an explanation of the purpose of the station and the important role it has played, and continues to play, with regard to Danish wind energy.

The Danish national Laboratory at Risø was established in 1958, primarily as a nuclear research facility. The rejection of the nuclear option by Denmark following intense opposition during the 1960’s and 70’s removed this strand of research, but the

laboratory had by then diversified into a number of other areas of interest. The Danish energy plan of 1981, whilst not totally removing nuclear as an option, opened up the possibility of greater expansion and research into alternative energy supplies and formalised political support for their use in the Danish energy mix. Staff at the research centre had already precluded this increased openness however, and personnel from the Centre's Reactor Technology Department initiated research into wind turbines at Risø in 1975. The National Test Station for Small Windmills was established there in 1975. Nielsen *et al*, in their 1998 history of the national laboratory, suggest that one of the primary motivators of the switch in the area of study related to a conviction by some researchers that "it would be possible to create a Danish wind turbine industry"(Nielsen, Nielsen et al. 1998). The test station has had an important role since this point.

Meteorologists at the station were responsible for producing the Danish wind atlas, which played a vital role in that it enabled estimations of potential for availability of wind energy to be made, initially onshore, and more recently offshore.

As has been noted already, the test station also had, and continues to have, an active role in the setting and enforcement of performance standards for turbine operations. Initially rising out of work to assess the performance of different turbine designs as part of the research process, the Danish Government formalised Risø's role when, in 1979, it linked provision of its 30% capital subsidy only to turbines which had been approved by Risø as meeting a certain performance standard.

Whilst the subsidy scheme was later replaced, the system for approval through Risø was expanded. Whilst it is possible to have a number of the tests associated with gaining a licence to install particular models of turbine carried out at a range of test sites in Denmark and Germany, only Risø is licensed to validate Danish regulations

on the testing of blades. In addition, “Denmark is the only country in which the law requires that all new rotor blades be tested both statically, i.e. applying weights to bend the blade, and dynamically, i.e. testing the blade's ability to withstand fatigue from repeated bending more than five million times.”(Krohn 1999) An important piece of regulation and one which may have implications for a number of companies, especially non-Danish companies, who might consider attempting to access the Danish market.

The researchers also worked closely with the turbine manufacturing industry, with which it had close links from as early as the 1970's. Undoubtedly this has led to a significant contribution to the development of the technology and its gradual up-scaling. The station played a considerable role in the informal knowledge gathering associated with the early days of Danish turbine manufacturing, but was also considerably involved with the formalisation of knowledge that was to become essential as the industry matured.

#### 4.4 The Role of Co-operatives

Another important social trend that began to have an effect at around this time was the increasing emergence of co-operative owned wind turbines.

The co-operative movement had first been taken up in Denmark in 1866 (Tranaes 1997a) and had been popular since the early 1880's. By the 1970's however, the merging of smaller co-ops from villages into larger town based units meant the villages were left without what had been a source of community spirit and purpose. Joint purchase and ownership of turbines presented the opportunity to not only revive community spirit, but to do so in a way which benefited the environment and which also presented the possibility of economic benefit. Morthorst has presented convincing evidence that the motivation for those involved in co-operative

owner turbines was only weakly derived from economic motivations. While able to show a strong link between the potential for profitability and the degree of capacity increase for single owners, no such link was apparent. Questioning of those with shares in co-operative owned turbines suggested that environmental motivations were regarded as slightly more important. The level of response to profitability has important implications for the application of economic mechanisms by government in trying to achieve particular rates of growth in capacity. (Morthorst 1999)

Co-operative ownership proved, and continues to prove, popular. At present, around 70% of turbines installed in Denmark remain in the ownership of single or groups of private individuals. Whilst the role of co-operatives has diminished somewhat, the role of individual owners has expanded in recent years (Morthorst 1999). It is presently not possible to comment as to whether co-operative and individual ownership of Danish turbines will continue with the shift to offshore wind exploitation.

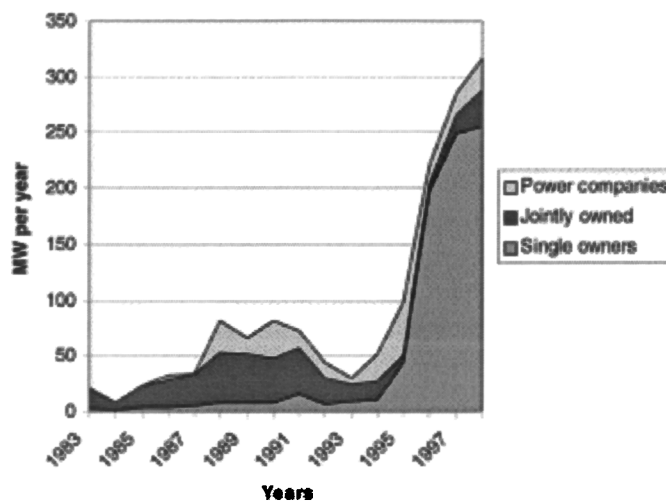
It has been estimated that 5% of Danish households have a share in turbine ownership. The involvement of so many ordinary members of the Danish public in the process of turbine construction and ownership has a number of important implications. Most significantly, by engaging the interest and involvement of so many members of the public it gained their support thus providing a base of political support both as an issue within Denmark and in terms of siting and approval turbines. Large-scale public ownership effectively provides an automatic constituency in favour of their development. The introduction of a Renewable Portfolio Standard in Denmark in 2000 may have some consequences for the continued role of co-ops in developing wind. The limits for onshore development of wind caused by lack of available sites are acting to restrict the possibilities for further expansion. The new

system may not allow private individuals to make profitable investments in offshore projects due to the higher costs involved in offshore siting, or at least not as easily. Thus co-operative ownership is less likely to transfer and may not feature highly in funding projects as the emphasis shifts to offshore production. The 40MW Middelgrunden development off the coast of Copenhagen however, is partially owned by individual investors. Interests in the 20 2MW turbines are split so that the local utility owns 50% and individuals own 50% in the form of 40,500 shares, thus maintaining the potential for locals to have a positive interest in support of construction of the turbines (Middelgrunden 2001). Middelgrunden, however, was approved prior to the adoption of Danish legislation regarding harmonisation with the EU's internal electricity market, and before the adoption of the RPS mechanism for funding of renewables to replace the REFIT mechanism. (Boyle 2000; Eskesen 2000) This may have some effect on the future financing of offshore turbines.

The role of co-ops in this situation has been a further reflection of one of the particularities of the cultural sub-system of the Danish national innovation system. It is an aspect of the sub-system that stems from a historical basis and thus may prove difficult to transfer to a culture where there is no current use of co-operatives, and where it would have to be almost completely instigated (or re-instigated) from a position in which it is a much more unusual phenomenon.

The importance of co-operatives may anyway have passed its peak. Their role diminished significantly in the latter half of the 1990's, the capacity installed by co-ops declining in both real and comparative terms, as the role of single owners, such as farmers, expanded (Morthorst 1999).

Figure 4.1 Capacity development of wind turbines split into different ownerships.



(Morthorst 1999)

Nevertheless, the co-ops hold an important historical role in driving the use of the technology, providing a market, and making the technology more socially acceptable by allowing a wide range of investors to enjoy its benefits. The continued large scale ownership that came with the co-operatives also provides the industry with a form of political constituency that may prove useful in lobbying regarding the future treatment of renewable energy support mechanisms.

#### 4.5 Danish Turbines and the Learning Process

Karnøe defines the time from 1980 to 1983 as the beginning of a period he labels the 'early industrialisation of wind turbines', succeeding what had previously been the development of the technology through the joint actions of entrepreneurs and environmental activists. The period saw intensive development in improving the technology and a rapid increase in the average size of turbines produced, a trend which has continued to the present.

What has frequently been cited as the most notable aspect of Danish development, most especially in comparison with the development paths followed, or attempted, in other countries is the nature of the learning process involved in

Denmark. The Danish development process was, in the majority, a product of a learning-based knowledge system. Valentin suggests that this can be regarded as an almost trial-and-error basis for dealing with complex problems. In such a system, knowledge is gained through experience and user-producer interaction is extremely important (Valentin 1989). Valentin suggests that alongside embodied knowledge, learning-based knowledge is dominant in its relevance to innovation. This would seem to be borne out by observation of the various national programmes for development of wind turbines.

The learning-based system forms a basis for a bottom-up strategy, the corollary of this is the 'top-down' strategy, with a more formalised basis and more reliance on science-based knowledge, including research-based knowledge, its collection and application. This top-down approach proved by far the most common in world-wide national turbine research programmes, with largely unsuccessful attempts to pursue such development in the USA, Germany, the UK and Sweden and even from those efforts made by Danish utilities within the Danish Wind Power Programme (Karnøe 1990). The major downfall of the research-led plans of these countries would seem to stem from a predilection for large-scale projects. A number of reasons have been suggested for why this path was so frequently chosen. Potential explanations include the desire for the immediate creation of large-scale machines which fit in with the then prevalent mentality regarding provision of electricity, reliant on centralised generation. This was backed with a philosophy suggesting that the bigger the machines, the greater the economies of scale which could be won.

Karnøe suggests the complexity of wind technology surprised the technological establishment (Karnøe 1990), a large section of which seemed to come to the problem with the preconception that it would simply require cross-application

of knowledge from the aerospace industry, an assumption perhaps that embodied knowledge could be used as the basis for innovation alongside science – that is, research – based knowledge. This assumption proved to be largely incorrect.

According to Gipe (Gipe 1995b, pp70), both Karnøe and Heymann came to the conclusion that German and US engineers had become overconfident in their abilities to solve technical problems given sufficient funding, though Gipe notes that not everyone is in agreement with this analysis.

While funding for research in Denmark was not available at anywhere near the levels provided to American and German researchers, Danish efforts did, as has been noted, have some Government R&D backing. This is notable for the way it was used. While the US focused on devising new designs, Danish efforts were directed towards the improvement of components which were general to a number of turbines. A policy, which it could be argued, is reflected in the continuing policy of companies such as NEG-Micon which employ a set number of blade designs, rather than attempting to change between designs to produce situation-specific blades at increased cost.

Another element worthy of note concerning Danish turbines and the ‘bottom-up’ strategy employed is that it led to turbines which enjoyed greater economic viability. While in theory they were weaker technically than many of the American and German efforts, in practice the Danish machines generally outperformed their rivals (Karnøe 1990). It is an oft-noted fact that the Danish approach, or Danish concept as it has become known, which has meant production of gradually increasing turbine size has led to the technical capability to build turbines of capacity equivalent to those used, mostly unsuccessfully, in the various Megawatt scale R&D



programmes of other countries. This has occurred at much lower cost to Denmark, and with the added benefits of profitability.

This period of early industrialisation coincided with significantly greater competition, as around a dozen new companies entered the market. Four of these, the previously agricultural engineering companies of Bonus, Vestas, Nordtank and Windmatic, claiming a 65% share of the market by 1982. Riisager's company dropped from a market share of 75% in 1979 to just 1% in 1982 (Karnøe 1990).

Karnøe presents convincing evidence that the next stage of in the turbine industries development was further industrialisation at an increasingly forced pace (Karnøe 1990). In just two years the Danish companies expanded rapidly, forcing changes in production technique towards a greater emphasis on mass production. They also developed an increasing involvement in other aspects of project development, such as risk and financing, considerations vital to ensuring increased customer interest. The main reasons for this expansion lay with the expansion of two markets, firstly, and perhaps most importantly, the Californian market, and secondly, perhaps less significantly, but with important implications for the long term survival of the industry, the growth of the domestic Danish market.

#### 4.6 The Californian Market

The Public Utility Regulatory Policies act (PURPA) (U.S. Congress 1978) was introduced by the US legislature in 1978, it opened access to the electricity generating industry to non-utility generators as well as offering a number of tax incentives with the aim of stimulating development. PURPA effectively acted to remove a number of institutional barriers to the growth of renewable energy. The act provided a subsidy of 10%, but effects were delayed as different states sought to interpret and implement the federal legislation. In 1980 the available federal subsidy

was increased to 15% and extended to apply through to 1985. A separate Congressional Act provided a 10% tax credit on investment, for a total of 25% on independent power generators nation-wide.

California then elected to offer a further 25% credit to encourage investment in alternative energy sources for a total available tax credit of 50%. Renewables were further encouraged by two events. Firstly, California's Public Utility Commission imposed a \$15 million fine on one of the largest investor-owned utilities in the US for failing to consider the use of renewables in their energy mix. Secondly, further encouragement was gained through the efforts of the then Governor, Jerry Brown, to encourage interest in wind energy projects (Gipe 1995b, pp32). The result was, by the standards of the time, a huge influx of financial support for both wind and solar energy projects. Gipe suggests \$2 Billion was invested in wind energy projects as a result of the programme.

The effect of the tax credits and other policies was effectively to push an industry into existence, and immediately into a boom. The effect on Danish industry was massive, 36 turbines were exported in 1982 and 300 in 1983 (Karnøe 1990) but the main boom period was to be 1984-1986. Companies from a range of countries were competing in the newly opened market, including Dutch, Belgian and British firms, in addition to the American and Danish manufacturers. The rapidity with which the market opened, and the possibility that it might not stay open, led to many new companies rushing to try to bring products to market. The result of this was a significant reduction in quality, and thus performance, of turbines. This reduction in production quality occurred practically across the board and, according to Karnøe, led to a reduction in the rate of product development and improvement of the Danish turbines. Nevertheless, in comparison with their competitors, the Danish machines

had the advantage. Karnøe points out that the Danish share of the Californian market moved from 1% in 1982 to 50% in 1986 (Karnøe 1990). Much of this can be linked to the effect that the creation of standards had had on raising the technical performance of turbines. Thus it can be seen as deriving from both the grass roots movement and its involvement with the early stages of the technology, as well as from the later involvement of the Government and the Risø test station.

The desire to meet the needs of the Californian market was also to have significant effects on the Danish industry.

Firstly the marketplace demanded an increase in the plate capacity of turbines in order to maximise land use and the industry thus had to develop a 75kW turbine, an advance on the 55kW turbine which was standard at that point.

Karnøe notes the scaling-up process required turbine producers for the first time to document the “technical character of the design”. Thus the design process was, forcibly, increasingly formalised, “the demand for better documentation ... brought along a more formalized function of product development” (Karnøe 1990).

The effects of this were to increase the knowledge base of the Danish industry and, despite problems occurring due to the rushed expansion of the industry to fill the market, improved performance from Danish turbines.

The rapidity of expansion had also required much increased employment of engineers, leading to many more individuals gaining experience in the field.

The U.S. tax credits were withdrawn in 1985 and the market collapsed. Danish world-wide exports dropped from a high in that year of 3486 turbines with a total capacity of 220MW to a total of only 140 turbines exported in 1988 with a combined capacity of 20MW (FDV 1999b) - a massive contraction of the market. For most of the companies involved this rapid diminution of their markets meant

bankruptcy, and this was the case for some of the Danish companies. The total collapse of the market however, was prevented by action which led to a much increased Danish domestic demand.

The general trend for the Danish domestic market at the time was growth, as can be seen from table 4.1

Table 4.1: The Danish Domestic Market 1983-1990

Year	MW capacity – Denmark domestic market sales	Number of turbines sold to Danish domestic market
1983	20.6	919
1984	7.2	216
1985	23.1	326
1986	31.7	358
1987	33	311
1988	82	457
1989	65.7	469
1990	81	432

(FDV 1999b; FDV 1999a)

Karnøe attributes this growth to the changes in the institutional set-up which acted to increase the profitability of wind power projects, these were;

“a) the increased reimbursement of energy excise tax (1984) due to falling oil prices;

b) new prices for sales to the grid;

c) 20% direct subsidy to dispersed installations (reduced from 30%) but 50% subsidy to installations in wind farm”

(Karnøe 1990)

All three of these factors resulted from policy initiatives on behalf of the

Danish Government. There are a number of possible justifications for their introduction. Denmark had by this time committed to looking for alternative energy sources, and Danish companies had also achieved some degree of dominance. If it was to achieve either the creation of an industry as an end in itself, or if it wanted to further explore the possibilities of large scale use of wind energy, it had to recognise that the continued healthy existence of manufacturers was essential to either goal, and to act to ensure their survival through a continued marketplace.

The increased profitability led to greater interest and to the stimulus of co-operative ownership. The role of the utilities at this stage, and until 1988, was limited largely to research within the Wind Power Programme. That year saw the beginning of the move to fruition of a deal between the Danish Government and the two main Danish utilities, ELSAM and ELKRAFT, in which the utilities agreed to between them construct 100MW of wind power capacity.

The result of the increased activity amongst both public and private generators was to drive up the volume of domestic market sales to a record high in 1988, a record which remained unbeaten until 1995. What was perhaps most notable was that the deal was realised in the year when Danish turbine export sales were at a nadir (FDV 1999b). The Danish companies who had seen their American market collapse thus had their own reasonably burgeoning domestic market to fall back on.

While a number of turbine manufacturers did go out of business as a result of the end of the Californian wind-rush, and indeed the leading Danish company became bankrupt, the Danish domestic market provided enough of a cushion for some to survive and indeed, to form the basis of the future industry. The effect of the policy was thus to maintain the existence of the industry, its infrastructure and manufacturing capability, and to maintain the embodied knowledge inherent in what

was still a sector very much based on ‘learning through using’, rather than a more formalised structure. Again this can be interpreted as the direct action of the Danish Government, once more reflecting its willingness to become involved in maintaining the existence of the industry.

According To Karnøe, the increasing toughness of the turbine market forced the remaining active companies to work to further improve the economic performance of their equipment. This led to a further increase in the formalisation of the design process as companies interacted to a greater extent with research institutions and significant improvements in the design and performance of turbines. According to the Danish Wind Turbine Manufacturers Association (FDV 1999b), the average wind turbine power rating of Danish turbines sold world-wide increased from 94kW in 1986 to 115kW in 1987 and on to 171kW in 1988, a trend which has largely continued to the present with considerable average capacity increases each year. Grin and van de Graaf (Grin and van de Graaf 1996) suggest this development of the technology occurred as a result of the joining of the two communities which had so far been attempting to further the development and use of turbines in Denmark up to that point. The grass roots movement which had led the way up to that point needed the more formal skills of the trained engineers that had carried out the work within the Government research programmes, and who could be brought into work on refining the turbines by the larger companies moving into the industry. As the Californian market collapsed and the domestic Danish market stagnated, bankrupting the older, smaller companies, the remaining companies adopted new management techniques and were forced to streamline the technology in order to remain competitive. Again the result was an increased formalisation of knowledge, circumstances which again agree with those predicted by Karnøe.

#### 4.7 Planning Issues

A further barrier which has to be taken into account in consideration of expanding wind energy usage, is that of siting and obtaining permission to use particular sites. Even in Denmark, this has caused some degree of controversy.

In the latter part of the 1970's a residency criterion was applied to turbine ownership such that while private citizens (and thus groups or co-operatives) were allowed to own as much capacity as they could install, each development had to be within 3km of their place of residence. The theory behind this being to restrict ownership of turbines to those prepared to live in their vicinity, rather than allow urban dwellers to benefit from subsidised electricity without any negative effects.

Following the Governments deal with the utilities during the 1980's a consumption criteria was introduced at the behest of the utilities in order to prevent individuals from purchasing turbines and becoming independent power producers. This allowed guild members to have shares in turbine projects equal to a maximum of 135% of their own consumption, with a minimum figure of 6000kWh.

The year 1992 saw a slight relaxation of the residency criteria to allow guild members to live in the borough where their turbine was installed or in any neighbouring borough. The consumption criteria was also increased to 150% of individual consumption with a 9000kWh minimum. November 1996 saw a further relaxation such that individuals could now own shares in projects generating up to 30,000kWh annually and only have to live or work in the borough where their turbines are located.

The relaxation in 1992 came about as part of the Law for Wind Turbines. While this was a useful change in terms of helping to expand the domestic market, more importantly it also introduced a fixed tariff rate to be paid by the utilities for any wind generated electricity. The Act also formalised the allotment of responsibility for meeting the costs of grid connection for wind turbines; this had previously engendered a considerable volume of controversy. The law laid down that turbine owners would henceforth be responsible for costs of grid connection, with the utilities responsible for strengthening the grid so that connection was workable.

While turbine owners and manufacturers might have wished for conditions regarding connection more generous to their own business, the formalisation of the financial responsibilities at least acted to make turbine purchase costs more transparent. More important was the fixing of the amount the utilities had to pay for wind generated electricity at 85% of the average charged to the consumer. The law formalised what had previously been an informal agreement between the utilities, the turbine manufacturers and the turbine owners. While the agreement originally applied only to turbines under 150kW, then under 250kW, it was later relaxed to apply across the board (Gipe 1995a, pp60).

The relaxation of both the residency and the consumption criteria can be regarded as attempts to utilise more sites by allowing the marriage of a greater number of investors to potential projects.

Further measures to increase the available sites include a Government mandate to each of the nations regions. This has resulted in the identification of more potential onshore sites than was expected, with the likelihood that these will be developed in the next few years.



Danish energy policy, including that relating to wind energy and other renewable energy sources was brought up to date with Energy21, published in 1996. This laid down Danish targets for wind energy, and discussed the motivators and aims of Danish policy. It set a target for onshore wind energy of 1500MW to be in place by 2005 (Danish Energy and Environment Ministry 1996). Danish onshore capacity moved beyond the predicted 1500MW onshore capacity in 1999 (WPM 2000).

#### 4.8 Development of the Industry during the 1990's

In comparison to the 1980's, the 1990's appear to have been a far more stable time for the Danish turbine manufacturing industry.

Fixed price tariffs remained as the central plank of subsidisation until January 1<sup>st</sup> 2000, when it was displaced by a Renewable Portfolio Standard (RPS). While in existence the fixed price tariff scheme (REFIT) compelled power companies to purchase electricity at a price equal to 85% of the average price paid for electricity by the Danish consumer. Wind was also exempted from, or rather compensated for, the imposition of energy and CO<sub>2</sub> taxes, both of which measures helped to make wind more competitive with respect to conventional electricity generators. This compensation may become even more significant as part of the transition process from the REFIT scheme to the RPS scheme. It may play a role in convincing potential investors of the economic benefits of turbine investment following the period of perceived lack of security caused by the change-over.

These subsidies helped to assure turbine owners, as well as potential owners, that the long term capital investment which is required to finance wind projects would pay off as the subsidy was committed in the long term.

The 1990's have seen continuous expansion of the world-wide wind energy industry and the Danish turbine manufacturing industry has capitalised on this.

However, whilst the volume of sales of Danish equipment has increased, overall market share has begun to decrease as competition from the industries of other countries impinges on sales. Particularly important is the Germany market which has grown to become the largest market in the world with 1571MW of wind power capacity being installed in 1999 alone (WPM 2000). Notably it is the single marketplace where Danish companies are not dominant. Though Danish companies do have significant sales in Germany, around two thirds of the markets demand is effectively captured by German companies on an annual basis (Hinsch 2000a).

While continuing to cater to the Danish domestic market, which has itself grown to be in the order of between 200-300MW in each of the years 1996-1999, largely due to the policies mentioned above, some Danish manufacturers have also begun to follow a much more aggressive policy with regard to overseas markets, an increasing number of which have been opened up in recent years as political commitments to reduction of pollutants from other energy generation methods are put into practice.

Different turbine manufacturers have responded to this with a variety of strategies. NEG-Micon has been perhaps the most aggressive, acquiring companies in the Netherlands, the UK and Japan, though by 1999 had begun to overextend itself and has since had to calm its expansion in order to remain solvent. A further popular strategy for Danish companies operating in foreign markets has been to enter into partnerships with local companies. Such a joint venture benefits from the technical expertise of the Danish turbine manufacturer and from the local business knowledge of the domestic operator. Notable examples of this include the Spanish company, Gamesa, which is jointly owned by the major Danish manufacturer, Vestas, and the Spanish power and banking conglomerate, Iberdrola.

#### 4.9 The Siting of Manufacturing Facilities

The nature of the turbine manufacturing industry entails a certain number of practicalities, most evident of these is that the size of the equipment involved is considerable, and this is particularly true of the turbine towers. The problems – and costs – regarding transportation of these is significant enough that it rapidly becomes cheaper to transfer production to an area in which significant installation is to take place. This factor has thus helped to shape the strategies of the wind turbine manufacturers in the international market.

The major Danish manufacturers, while competing directly in the European market, have tended to each focus on different areas for their efforts in the developing world.

The need to have manufacturing bases near to markets has a number of implications, in some ways making the industry more attractive to other governments. For example, the need to site manufacturing facilities near to those sites where turbines are required effectively means that employment opportunities are exported from Denmark to other nations. As well as this obvious gain it can also lead to increased expertise in an industry, and increase the knowledge base of workers in the host country. This is particularly relevant to countries that form potential markets in the developing world in terms of the opportunity to gain access to new technology.

The potential size of, for example, the Indian market for wind power is large enough, and thus desirable enough, that the Indian Government can impose restrictions on the actions of incoming companies. Danish companies were the first to gain access to the Indian market through a number of joint ventures with domestic companies. Spanish regional governments have been able to set similar restrictions, with the result that they have managed to drive non-Spanish companies to invest

considerable funds and provide significant employment opportunities in their regions. The Spanish example will be discussed in greater depth in a later chapter.

Another strategy that has reflected the strength of the Danish manufacturing industry, most particularly with regard to the development of domestic industries, is the Danish drive to expand. This has seen their take-over of a number of companies in other countries. Examples include the purchase of the UK companies, the Wind Energy Group (WEG) and Taywood Aerolaminates from Taylor Woodrow by NEG Micon in early 1998, and the take-over by the same company of the Dutch turbine manufacturer NedWind BV in October of 1998. NEG Micon were themselves the result of a merger of the Danish companies Micon A/S and Nordtank Energy Group A/S in July of 1997. (FDV 1998; WPM 1998b)

#### 4.10 Innovation in the Danish Turbine Manufacturing Industry

Karnøe characterises the development of the Danish turbine industry into three phases; emergence, consolidation and maturity. When this statement was made, in 1990, Karnøe suggested that the industry was in the consolidation phase. Karnøe further suggests that development of wind technology is a highly complex undertaking and involves a high degree of uncertainty and that thus there was a need for a high degree of learning-by-using in the innovation process for the technology. This is juxtaposed with the role of science-based learning in the process. He concludes that learning-by-using was practically the sole source of innovation during the emergence stage of the industry, but that science-based learning began to have some impact during the consolidation phase and would increase in influence as the industry matured, predicting they would have a roughly equal role in continuing development by the mature stage. Karnøe points out that learning-by-using is likely to remain of considerable importance and that “the in-house knowledge base of the

firms is the base of the firms is the alpha and omega of the development of wind technology” (Karnøe 1990), with science-based advances acting as a supplement in the development process. Andersen and Jensen (Andersen and Jensen 1997) concur with Karnøe that the wind turbine industry had yet to reach maturity in 1997. They effectively predicted that such maturation would have occurred by 2030, and detailed a number of implications they expected this to have for the industry, including the existence of large stable markets by this point, and the likely exhaustion of new concepts being introduced to the marketplace.

#### 4.11 The Renewable Portfolio Standard

The Renewable Portfolio Standard (RPS) is a financial mechanism based on a concept developed in 1995-96 by the American Wind Energy Association and the Union of Concerned Scientists. In general terms, it requires “all generators or retail sellers of power to demonstrate, through ownership of ‘tradable energy credits’, that they have supported the generation of a certain amount of renewable power” (Rader 1997). Whilst in Denmark, the new RPS legislation actually puts the onus at the level of the individual consumer, these are effectively represented through their supply companies.

The change from the fixed tariff scheme to the RPS has been made for a number of reasons. The primary reason is the intention to increase the level of competition in the wind energy supply field, and as a result, bring down prices. There are a number of motivations for this; Denmark’s commitment to having 20% of its energy from renewable sources by 2003 requires further expansion if it is to be met. Additionally, the European Union’s moves towards the opening of electrical markets raises two linked problems. The European Commission wishes to see all RE support mechanisms in the EU harmonised in order to remove distortions in the market. In

line with the same directives, the Union, more particularly the Directorate for Competition, DG IV, has expressed the opinion that the scale of the subsidy that is now required annually to provide payments within the fixed tariff scheme in Denmark had grown such that it was becoming unacceptable.

The nature of the REFIT mechanism means that the burden of paying the continually increasing sum of the subsidies for wind will continue to increase year on year. Continued high level increases in the total capacity of wind turbines installed mean that the total sum of subsidy pay-outs has increased annually at significant rates. Subsidising the industry at this level could not realistically be regarded as economically sustainable for much further into the future. The REFIT mechanism can be said to have achieved part of its aims, in that it has helped to support the installation of a large volume of turbines. It seems likely that one aim of the RPS is to try to continue the expansion of capacity, whilst also acting to reduce the total burden to the consumer, at least in terms of cost per electrical unit generated. It is possible that the percentage obligation inherent to the RPS system and linked to Danish targets for wind installation will bring cost increases for the consumer. The central aim of the introduction of the RPS is that these will be lower than if the REFIT system was employed to drive the same level of use of wind.

The hoped effect of the introduction of the RPS is to gradually increase Danish renewable energy use by forcing electricity consumers to create a market which will then be filled by new generators. The mechanism includes a price cap, which enables consumers unable to gain access to renewable generated electricity in sufficient quantity to meet their obligations to use non-renewably sourced electricity paid for at a premium. Thus, if renewable energy generators do not come online with prices below the price cap in sufficient quantities, the consumer will pay this upper

limit. Naturally, this will mean a shortfall against the projected targets for the size of the market created and the amount of electricity generated from renewable sources.

It is also possible that the RPS was introduced in Denmark to anticipate its possible introduction as the most likely mechanism for a harmonised European-wide renewable energy subsidy scheme. It is known that the Competition Directorate of the European Commission, DG IV, favours an RPS style mechanism as the instrument of choice should a harmonised programme to encourage RE ever come into place on a Europe wide basis. Though the opposition to it in certain EU countries, most notably Germany to such a harmonised scheme is great enough at present that this is likely to be only a minor concern in comparison with the expressed need to reduce costs to the Danish electricity consumer. The nature of a REFIT mechanism for the support of renewables is such that it tends to mean steadily increasing costs on an annual basis. Figures for the total cost of the Danish REFIT are shown in Table 4.2.

Table 4.2 Wind Turbine Subsidies, 1993-1998 (DKr million)

	1993	1994	1995	1996	1997	1998
Production subsidy						
Wind 0.10 DKr	100	118	136	122	193	216
Wind 0.17 DKr	134	153	165	155	262	390
Tax Expenditures	67	67	69	76	83	88
Price Subsidy	143	158	165	157	256	359
Total	444	496	535	510	794	1,053
Unit Subsidy, DKr per kWh	0.43	0.44	0.46	0.42	0.41	0.38

(OECD 2000, pp126)

In this six year period alone, subsidies from the public purse totalled nearly DKr4 billion, with the total for following years likely to be in excess of DKr1 billion annually. (OECD 1988, pp125)

What should also be noted however as a further contributing factor to the change, and at odds with the opinions of the vested interests of industry representatives, is that the profit margins of the Danish turbine operators have been steadily increasing. Whilst the subsidy available per kWh declined by 11% in real terms between 1990 and 1998, the operating costs dropped at approximately four times this rate. An OECD report suggests that the average wind turbine installed in 1998 can produce a kWh at a cost of around DKr0.32, and sell it for around DKr0.60, representing a near 100% margin, and giving a 10-17% rate of post-tax rate of return. In 1990 the margin was around 5%. The RPS was thus also likely to be motivated by the knowledge that the burden on consumers could be significantly reduced without prejudicing the future economics of new turbine projects. (OECD 1988, pp126)

Largely independently of any eventual harmonised mechanism though, significant pressure to reduce or remove subsidies has come from the Competition Directorate of the European Commission. The guidelines on the levels of state aid that can be allotted to environmental protection, that is, the extent to which governments can subsidise their environmental industries, expired at the end of 2000. The present competition commissioner is regarded as being keen to place tougher limits within the new guidelines currently in preparation. Subsidy schemes following the REFIT model could be one of the mechanisms hardest hit by the new guidelines, if they conform to the expectations of the trade press (Hinsch 2000b).

Whilst there are plenty of possible reasons justifying the switch to the RPS mechanism, the new mechanism is not without problems. Whilst the RPS has officially been put in place from January 1<sup>st</sup> 2000, the trading exchange for green power credits will not open until January 1<sup>st</sup> 2002.



The change in mechanism also shifts the responsibility for the paying of premium prices from the state to the utilities, which are effectively responsible for ensuring their customers adhere to purchasing the minimum renewable sources electricity. As it stands at present, the RPS will provide an almost immediate reduction in the prices paid for wind generated electricity. Payments under the REFIT mechanism typically totalled around DKr 0.60/kWh. Under the RPS mechanism as it was first announced, electricity was to be paid for at the base rate of DKr 0.33/kWh for a minimum ten year period, plus DKr 0.27/kWh for the first 12,000 to 25,000 “full load hours of operation”, with the number of hours at this rate dependent on the size of the turbine. Once the allotted figure for generation hours had been reached, turbine owners would receive ‘green certificates’ which would be eligible for trade within the trading exchange from 2002, subject to a minimum floor of DKr 0.10/kWh. Three weeks after the introduction of the RPS mechanism however, it was announced that there had been a misinterpretation of the new law. Within the new interpretation, owners wishing to receive green certificates have to forego the DKr 0.33/kWh payments after 10 years. Present prices for electricity in Scandinavia are around DKr 0.10-0.12/kWh. The wind industry trade journal, Windpower Monthly suggests that the newer interpretation will mean that owners of turbines older than ten years will face a drop in income from 2002 to between DKr 0.20 and DKr 0.37/kWh. Turbines contracted for from 2000 will receive DKr 0.33/kWh plus between DKr 0.10 and DKr 0.27/kWh, both effectively taking a cut on the payments received under the REFIT mechanism. The new interpretation has led to objections from the turbine owners association who had previously not objected to the new mechanism (Moller 2000).

The effect of the new mechanism, and of the problems relating to its interpretation, has been to increase the perception of insecurity with regard to

potential investment in new wind turbines. The consequences of this were to cause domestic Danish turbine sales to drop to zero for the whole of the year 2000 (Moller 2001). The implications of this may be quite severe, as has already been discussed, the existence of the Danish domestic sector is of considerable importance to the Danish turbine industry. Its removal, even for a relatively short period, may have serious implications in terms of the level of business that Danish companies have access to. Removal may also have the potential to retard the level of competitiveness and innovation amongst the industry as a whole domestically, and thus possibly reducing their ability to compete internationally.

#### 4.12 The Development of the Danish Turbine Manufacturing Industry in the context of the Danish National Innovation System

There are a number of facets of the Danish National Innovation System (NIS) that have proved appropriate to the development of the wind turbine industry.

Firstly, the Danish political system has been such, that a consensus is more easily reached than is perhaps the case in some other countries. This has meant that it has been easier to achieve a cohesive long-term energy plan. The overall result of this has been to provide renewable energy projects, and those considering investing in them, with a transparent, long term framework in which to operate. The fact that renewable energy, and wind energy in particular, have specific political support for their growth is simply a further advantage.

Aspects of the Danish cultural subsystem of its NIS also provide a significant part of the foundations for development of a wind industry. Historically, windmills have been significant providers of energy in Denmark providing a cultural background as a proven source of power and acting to stimulate the early research of pioneers such as La Cour and Juul, which, it can be posited led to the beginnings of

the Danish base of knowledge regarding turbine production and operation. These, along with many of the other pioneers of turbine development also reflect the grass roots involvement that is strong across Danish society (see, for example, Andersen 1997), and which was significant in moving forward the process of industrialisation, both in terms of further developing the knowledge base and in increasing awareness of the technology and the political issues surrounding it. Further aspects of the importance of Danish culture in the development of its wind turbine industry include the co-operative movement, which, while not unique to Denmark has maintained a significance in rural areas. It is these areas which have helped to form the basis for the Danish domestic turbine market.

Another relevant aspect of the Danish social system concerns the role of siting of turbines and the winning of necessary permissions for construction. Danish legislation places a range of restrictions on potential sites which limits the potential capacity which might be achieved nation-wide, including protection of woodland and amenity, and have restricted siting with respect to ownership of turbines. The obvious effect of such measures is to lower the number and overall capacity of turbines to be installed and thus to act as a barrier to expansion of the technology. However, another factor to be taken into account, is that unimpeded growth of turbines has the potential to lead to increased opposition. The initial lack of responses to the Danish Government's efforts to find additional sites for expansion of wind power by compelling individual boroughs to compile lists of potential new sites might suggest that some opposition had been engendered. It is, of course, not possible to calculate a balance point between these two factors in order to maximise absolutely the volume of capacity installed, however the Danish system does seem to have achieved a balance of protection and expansion through the inclusion of large numbers of people

in ownership of the technology, a further reflection of the benefits of the co-operative system prevalent in financing the technology. Denmark has thus managed to find enough sites to continuously achieve, and often outdo, the targets set for wind energy expansion.

The willingness of the Danish Government to become actively involved in legislating with regard to siting of wind turbines can perhaps be regarded as just one aspect of a willingness on its part to involve itself in regulation in order to try to achieve significant changes in society and in the market. The Danish Government has felt able not only to subsidise growth of the new technology but to act to enforce the involvement of the utilities. Their involvement has been compelled both in terms of having to purchase the technology itself and in having to pay a set price for the electricity produced from those wind powered generators not owned by the utilities. While not unique to Denmark, an analysis of other nations' approaches to regulation, particularly with regard to renewable energy would perhaps suggest that regulation of this kind would be more difficult to achieve in a range of other countries. That this is possible in Denmark is a reflection of the particular cultural subsystem at work there.

The actions of customers can also impact on the market/industry system of an NIS. In the case of Danish turbine manufacturing industry, this impact had a significant role in the development of the technology. Notable were the efforts of the Wind Turbine Owners Association. Their publication of regular statistics regarding the technology and its performance acted to protect the consumer and to force an increase in the quality of the product. This was particularly relevant in the early stages of the industry, though it has become less so as other, more formal mechanisms for customer protection increased in importance.

Porter identifies “rivalry at home” (Porter 1990b, pp662) as benefiting national industry in a number of ways. It helps, for example, to maintain the level of sophistication of domestic customers which acts as a self-reinforcing measure in maintaining improvement of standards in an industry and thus to the maintenance of a positive advantage in the global marketplace. Porter also concludes that having a range of competitive companies operating in the domestic market tends to act to prevent, or at least limit, the protectionist policies which can occur if the domestic market is dominated by a “national champion”. Porter presents evidence that such protectionism is inherently damaging to the global performance of an industry if it occurs in the domestic market (Porter 1990b; Porter 1990a).

One interesting aspect of the present situation in Denmark is the increasing level of mergers and take-overs which have occurred recently, Porter acknowledges that this behaviour can lead to short-term profits which appeal to the management of those companies involved. Obviously, this short-term opportunism is difficult to prevent, but Porter also suggests that for the industry as a whole this is damaging in the long term. It is further suggested by Porter that one of the primary roles of a nation’s government is to act to ensure “vigorous domestic rivalry” (Porter 1990b). It would be premature to suggest that the present level of mergers will constitute any threat to the continuing dominance of the Danish wind turbine manufacturing industry in the world market, nevertheless the potential is there for problems to occur. What they might represent though, may be evidence of a potential change in the industrial phase of the industry as a whole. It is suggested as part of this research that a change in the industrial phase of the industry, from the growth to mature phase, may be looming. This is discussed at length in Chapters six and eight. The move to a small number of large, vertically integrated companies from a larger number of smaller

countries can be regarded as an indicator of such a shift. An executive of one of the major Danish manufacturers has suggested that the eventual existence of only two or three major manufacturers is a distinct possibility. Andersen and Jensen (Andersen and Jensen 1997) concur with this prognosis, and the president of the European Wind Energy Association, Klaus Rave, has suggested that a move to bigger companies might more easily enable the level of investment necessary to expand the wind turbine industry in a fuller range of countries (Aubrey 2001).

One feature of Danish industry which may have acted to limit the movement towards increased mergers may be a cultural leaning toward smaller firms. SME's dominate Danish industry to the extent that only 2% of companies have more than 50 employees (Monsted 1989). The successes that Danish companies have enjoyed in global markets has been achieved in a large part by smaller companies, thus there is no cultural imperative that a firm must be of substantial size in order to compete internationally, as it might be suggested is the case in some countries. What may be an interesting aspect of the dominance of such small companies is that it may make them more vulnerable to take-over by larger companies, perhaps even multi-national corporations should the marketplace become attractive on the large scale. This appears to be increasingly the case with some RET's. This is most notable with regard to PV, though the recent entrance of ABB into the wind turbine marketplace may indicate that turbine manufacturing may have begun to attract the attention of much larger operators (ABB 2000). A movement towards the involvement of larger companies may be a further indicator of a shift towards maturity of the industry. It should be noted that the trend for increasing average turbine capacities means that investment in the development of technology by potential new entrants to the industry is likely to become more and more difficult, and seems likely to act to favour larger

companies with the capital to either invest in new technology or buy up existing technology (Andersen and Jensen 1997).

Porter warns that protectionism in the home market tends to act to reduce competitiveness by insulating companies, and their profits, from the market. If protectionism has occurred with regard to the Danish wind turbine industry it is difficult to calculate to what extent any damage might have this occurred and what impacts it is likely to have had. However, it would seem that the Danish domestic market remains the most competitive in the industry, as indicated by the lack of willingness of non-Danish firms to attempt to access it. The industry appears to have avoided this pitfall.

An interesting facet of the early stages of development of turbines in Denmark in the context of the national innovation system is the way in which the various subsystems of the technological system worked. A considerable portion of Danish policy regarding research and the application of the science connected with the nascent technology was similar to other nations in a number of respects and shared similar poor results. It was other more unique qualities of the Danish system, largely again actions at the grass roots level, that allowed an initial level of knowledge to be built up, reflecting a research subsystem that can operate effectively in this circumstance outside what might be regarded as the conventional one in many countries (Karnøe 1990).

In addition to a simple and open system of public support which acts to provide increased certainty to investors, there are a number of qualities of the Danish National Financing System which have affected the enablement of the turbine manufacturing industry. Mitchell (Mitchell 1994) discusses these in order to effect the differences between the Danish and the UK NFS, detailing a number of financing

options available, as well as other factors relevant to the financing of wind energy projects in Denmark.

Single turbine owners, largely farmers, can generally access up to 100% of project capital costs from local banks or building societies for a good site, with societies lending at a lesser rate than banks. Mitchell points out that the flexible banking system means that there are a range of options available and it is thus much easier for such small-scale developers to arrange 100% equity and thus avoid having to provide their own funds against the turbine development.

Financing of turbines under collective ownership can follow a range of slightly different paths. The two most common involve investors borrowing from a bank to finance their share of the turbine and either receiving their returns directly and using this to pay off their loan or with the returns going directly to a central bank account until all costs have been met. This second method is particularly attractive as it means that beyond acquiring a loan and the initial paperwork needed to be completed to initiate investment no effort is needed by the individual investors to maintain payments or any other aspect of the development.

Bank loans are often arranged with an investor's own bank. Alternatively Denmark has a range of 'ethical' banks which are willing to loan money to projects such as wind turbine construction at generously low rates of interest. Investment is incentivised by the tax-free status allotted to wind turbine equipment. Mitchell emphasises that the potential for investment exists within the context of the rest of the framework of Danish circumstance as has been detailed above. Mitchell also suggests that a product of the clear Government policy regarding wind power, and of the development of a mechanism to ensure high product standards, has been increased confidence on the part of Danish banks and building societies towards investing in it.



The result has been that banks regard loans for wind turbine investment as commonplace and usually will not even require collateral against them. Mitchell notes the existence of the centralised Danish tax system which allows easy checking of individuals credit worthiness allowing for easy assessment of the level of risk relating to provision of a loan by the bank.

Mitchell finally concludes that the financial system has been a further factor in enabling the increased penetration of wind power systems in Denmark. By default this means the Danish NFS is also more applicable to assisting the innovation process through allowing increased uptake of the technology. This leads to a further increase in the knowledge base of Danish industry as well as allowing easier investment in Danish industry and permitting its expansion through an increase in the size of the market, and thus of the volume of business which can be accessed.

#### 4.13 Protectionism in the Danish Turbine Manufacturing Industry

As has already been discussed in chapter three, and elsewhere, protectionism plays a significant role in the development and growth of new technologies and industries. A range of policies aimed at assisting the growth of an industry in a particular country was discussed in general terms in chapter three. The questions which will be addressed here are whether Danish policy has been protectionist of the Danish turbine industry, or whether it has simply been directed at removing the barriers to the expansion of wind energy usage, and which the Danish wind industry happened to be best placed to take advantage of. The second of these options does not preclude that Danish policy was aimed at taking advantage of an opportunity that had been identified. Obviously, there is the potential for a high degree of subjectivity in any assessment by members of the industry, depending on their positions relative to the issues.

Analysis begins with the most basic strands of Danish policy, funding of research and development and education in use of the technology. Whilst it is possible to argue that in the context of the free market, companies should fund their own efforts in these categories, in reality all nations provide support for the creation and growth of new industries as one of their most basic functions. A considerable portion of the initial Danish efforts in wind energy technology research mirrored that of other countries, with a significant fraction of Government originated funding going to large-scale projects and to the science-based technology innovation efforts common to a range of countries at the time. That governmental research efforts switched to a greater focus on smaller scale examples of the technology can perhaps be regarded as only a response to the direction in which the technology was already moving in the country. It is not necessarily a reflection of the setting of an agenda by the Danish authorities, more a changing of that agenda to take into account the greater success that had come with the alternative, learning-based approach which had emerged from the efforts of the grass-roots movement. Furthermore the funding provided for R&D efforts was small in comparison to the levels being applied in other countries at the same time, and it would be difficult to argue that Danish funding gave advantages to its industry that were out of line with the efforts of its competitors.

One of the greatest advantages to the industry was, undoubtedly, the close ties between industry, the Government, and its agents. Close consideration allowed the easy transfer of results from government R&D to commercial usage. Mechanisms to aid this transfer were specifically put in place, and these drew in the involvement of both the Ministries of Energy and of Industry. These R&D efforts were carried out by both public and private sectors and backed with public funds to try to ensure commercial products. This close collaboration, began as long ago as the late 1970's,

has continued to the present, though the form of the support has changed considerably in that period. (Maribo Pedersen 1990; Øster and Jacobsen 1990)

In terms of education and increasing the knowledge base of workers to the advantage of the industry, a large part of the initial knowledge gathered came from the direct actions of those within the field and in the nascent industry itself. The Risø test station acted to both improve the level of knowledge concerning turbines and to formalise what was already being practised. In conjunction with a number of mechanisms which were again a reflection of the grass roots origins of the industry, thus raised the quality of turbines. Thus, while furthering the industry through increasing the quality of its products, the station also acted to improve standards and to protect the customer, though, of course, this is not the same as being protectionist.

The initial actions of the station in improving standards were carried out in conjunction with the application of a 30% subsidy from 1979 to 1989 to encourage greater take-up of the technology. This can be perceived as a protectionist measure in the sense that it acts to insulate the technology from having to compete on level terms with other energy providers, though this can be justified on public interest grounds. In terms of protecting the industry from non-Danish turbine manufacturers, this was largely unnecessary due to the lack of such competitors in the wake of the crash of the Californian market. The world industry has grown but the need for a Danish domestic industry has remained, and the advantages of keeping the suppliers to that market Danish in origin have become increasingly important to the Danish economy. Policies aimed at maintaining and increasing the use of the technology domestically, can be linked inextricably with the origins of several of the companies which are now amongst the largest in the industry globally. In this context the subsidy acted to initiate Denmark and Danish companies as the world market leaders. It is difficult to

judge however, what were the precise intentions of the Danish government in creating the policy. As has been discussed, increasing energy security had a major part in driving Danish energy policy at the time and this relates to the wish to develop indigenous energy sources. The seizure upon a technology which was already beginning to be developed in the country, semi-independently of the Government's efforts, was thus an obvious one. In this case the technology was at an early enough stage that the intercession of the Danish Government was merely to provide a seed capital to test the appropriateness of the technology to the market. Indeed Denmark had such a range of potential motivators at the opening stages of the wind energy industry that it is possible to regard the potential for future exploitation of a world market as only one motivation amongst many, though there seems to be sufficient evidence to indicate creation of an industry was a motivator, and did have an impact on the specific shaping of policy.

One interesting aspect of the operations carried out at Risø undoubtedly relates to the Danish certification programme for wind turbines. To install a turbine in Denmark, it is necessary to meet a range of criteria regarding its safety and performance. This includes testing of blades, blade hub, main shaft and main-shaft bearings, machine frame, yaw system, tower, foundation and safety systems. Testing regarding certification for most of these can be carried out at places in both Denmark and Germany. Only Risø can perform the tests for systems and concepts, and for blades (Risø 2000).

The standards which Denmark applies to the testing of blades in order for them to achieve certification and thus be allowed to access the Danish market are uniquely tough. "Denmark is the only country in which the law requires that all new rotor blades be tested both statically, i.e. applying weights to bend the blade, and

dynamically, i.e. testing the blade's ability to withstand fatigue from repeated bending more than five million times" (Krohn 1999). Whilst this regulation applies to all companies wishing to sell turbines in Denmark, there is considerable evidence that this kind of regulation has a disproportionate impact on those trying to enter a market from outside, as was described in chapter three. The major economic effect of this is to drive up costs for manufacturers wishing to enter the Danish market, thus rendering them even less capable of competing with the established Danish companies.

It is interesting to note that Danish industrial policy in this area has created significant controversy in terms of international environmental regulation. The Danish Bottles case, wherein Denmark introduced regulation as to what kinds of drink containers might legally be sold in Denmark, with approval for new containers having to be sought from a specified laboratory. The measure was challenged through the European Commission on the grounds that it was a trade measure masquerading as environmental protection, but was allowed to stand, and is a landmark case in European environmental regulation. There is little doubt that whilst serving its aim of increasing recycling of products, it has also achieved reduced imports into Denmark. Clearly there are some parallels here with the use of the Risø test station, though it would be unwise to claim that these two points are the basis for Danish industrial policy.

One interesting plank of Danish policy during the early stages of the wind turbine industry, in terms of the development and support of the industry, was the Government's decision to compel the two major Danish utilities to purchase 100MW of wind energy capacity. Whilst again the Danish need to expand the range of available power sources could be used to explain the decision, it did come at a point when the industry was facing the removal of its then only significant marketplace,

California. This policy created a cushion which allowed the industry to survive while a marketplace grew again. It also helped to foster greater ties between the utilities and the industry and aided greater facilitation of application of research results between the two. It seems likely that maintenance of the industry played a significant part in driving the creation of this policy.

Danish energy policy has included a number of strands which have acted to bolster the domestic market for wind turbines. These actions have certainly acted to advantage the growing industry and protect it from outright competition from other energy producers, it can be noted however that there have been a number of other reasons which have been, or could be suggested to be, the stimulus for the implementation of each aspect of policy.

The tax breaks made available to encourage take-up are obviously explicitly aimed precisely at encouraging greater use of wind technology and the continuing reductions in the restrictions on ownership of turbines by individuals can be ascribed similar motives.

Notably, the capital subsidy for turbine purchase was discontinued in 1989, after being offered for a period of ten years, once it was judged to be no longer necessary to stimulate purchase of the technology through such a mechanism. The implementation of the standard fixed price in the form of the REFIT scheme could be seen as a protection of the domestic industry from the more established generating technologies. It could also however be perceived as going some way to taking into account the differences between wind turbines and larger more traditional generators in terms of their effects on the environment and the way they fit into the grid system.

Whilst it would be possible to use a REFIT mechanism in a manner protectionist to Danish companies, it would be difficult to do so whilst maintaining

any level of transparency. Such a motivation would be obvious and would soon draw complaints and legal challenges from competitors within both the EU and WTO complaint mechanisms. Further to this, when the REFIT was first established in Denmark there would have been little need to use it to protect Danish companies, the level of competition being negligible. As the wind turbine manufacturing industries of other countries have expanded to the point where they are no longer dominated by the Danish firms, protectionism may have appeared more attractive. For the reasons mentioned above any protection would have to come from the application of mechanisms outside of REFIT.

Development of the industry has inevitably become more of an issue as the industry has begun to grow and become a significant one in the Danish economy. Windpower Monthly, a trade journal for the industry, claimed that by the end of 1997 (WPM 1998a) the wind turbine manufacturing industry was the third largest exporting Danish industry. Maintenance of the market for turbines in Denmark thus has serious implications for the Danish economy, if one subscribes to the argument that a strong domestic market is the key to continued success in the world marketplace as Porter and others suggest (Porter 1990b). In this context, it is interesting to note that present Danish policy regarding the use of wind turbines is to pursue the development of increased use of offshore turbines (Danish Energy and Environment Ministry 1996; Danish Ministry of Environment and Energy 1998; Eskesen 2000).

#### 4.14 Offshore Wind

The availability of onshore sites in Denmark is low, the Energy 21 document published in 1996 and detailing an action plan for Denmark's future energy needs, calculated, somewhat conservatively, that sites for up to only 1500MW existed on the Danish mainland. Windpower Monthly (WPM 2000) calculated that 1747MW was in

place by the end of 1999. The 1500MW figure may have been low for two reasons. Firstly, the Energy 21 report did not make clear whether it took into account the potential for the replacement of older, smaller turbines with larger, newer ones in order to improve the exploitation of sites, though anecdotal evidence from one Risø researcher suggests this is not happening to any significant extent. Secondly, the figure was also revised upwards following the application of policy by the national Government requiring Danish districts to assess their potential for turbine siting. It is unlikely to be long, however, before the full onshore potential is achieved. Without some alternative, the result of reaching the limit would be the culmination of the domestic market and the emplacement of limits on Denmark's stated goals of increasing renewable energy capacity so that it fulfils an extra 1% of Danish energy needs each year, and so that renewable energy contributes to around 35% of Danish energy needs by 2030.

To mitigate this Denmark has placed an increasing focus on offshore wind energy technology. Energy 21 estimates that there is the potential for around 4000MW of wind power capacity in Danish waters. Development of the technology to exploit this would allow Denmark to maintain its commitment to the environment both domestically and internationally, it would also mean a continuing domestic market for the Danish turbine manufacturing industry and actually help to extend the product range of Danish companies. Denmark can focus its efforts on research and continue to support the efforts of its industry to thus improve the product. Energy 21 also contains an explicit confirmation of the Danish Governments desire to see continued expansion of renewable energy technologies, it prioritises research and development of renewable energy, particularly wind power and biomass, with the



express aim of creating increased employment opportunities and exports, noting that these would be the rewards for investment in the fields.

Morthorst (Morthorst 1998) notes a 1997 report which predicts that by 2000, offshore wind farms utilising 1.5-2MW turbines would be capable of producing electricity within the price range usual to onshore turbines.

The biggest difficulty in trying to differentiate between the multiple motivations for Danish policy perhaps stem from the fact that Denmark's turbine manufacturing industry has so completely dominated its own home marketplace. In the early days of development this can be attributed to the fact that Denmark was so dominant in the industry. Any efforts to encourage the use of wind energy for its own sake within Denmark were thus bound to result in increased sales internally. However, as other significant manufacturers have arisen, Danish companies have continued to dominate the Danish market to such an extent that sales by non-Danish companies within Denmark are negligible. Thus while it could be argued that any efforts to expand the scope of the domestic Danish market is effectively bolstering the Danish manufacturing industry, it is also possible that non-Danish companies regard the market as too difficult to penetrate and thus do not seriously attempt to do so. Plausibly it is possible that part of the perception of Denmark as being so highly competitive would stem from any additional difficulties provided by protectionist policies.

It is possible however that the shift to offshore wind development forced by the increasing paucity of onshore sites in Denmark will offer non-Danish companies the opportunity to gain access to the Danish marketplace. The German-based arm of the American Enron group have set up facilities in Denmark with the aim of bidding

to supply turbines to the substantial new projects that the Danish Energy Ministry has announced it intends to develop offshore.

Clearly, there is a significant advantage which continues to devolve from the first mover status of Danish turbine manufacturing. This applies both in terms of knowledge capital and with regard to policies that can be developed which act to effectively defend Danish companies established position, and do so without breaking any of the international agreements on the use of regulation to protect markets.

#### 4.15 The Behaviour of the Danish Turbine Industry in the World Marketplace

Clearly, the opportunity for the provision of assistance to Danish industry by the Danish Government is somewhat limited outside the confines of Denmark itself. Nevertheless, Danish companies dominate the world market for wind turbine equipment. Whilst Denmark's companies continue to benefit from first mover advantage, this is bolstered by a number of policies aimed at helping to support and promote the expansion of the industry around the world.

Denmark's pioneering of the technology continue to give its companies an advantage in terms of the having the greatest experience and knowledge relating to it, and this lends itself to providing an advantage in open competition with the turbine manufacturing industries of other nations. The Danish Government has realised both the potential of the market world-wide and the significance and importance of that market to the Danish economy. It has acted to try to help to promote the industry overseas via trade fairs in a range of countries with the potential for wind power usage and with the expressed policy of encouraging renewables. The Danish Government has also placed wind turbines into a number of deals linking trade-to-aid whereby the Danish International Development Agency (DANIDA) undertakes to provide aid to developing countries on the condition that the funds thus provided are matched with

specified amounts by the Government of the country receiving the funds and used to purchase Danish wind turbines. Thus, Denmark fulfils its commitment to provide funding for developing nations and at the same time bolsters its own industry. Effectively this policy is a protectionist one which can operate outside the domestic environs of the country itself. This provides a further subsidised market for its companies manufacturing output, with the remainder paid by overseas customers. This can aid in the expansion or even creation of new markets, allowing Danish companies to be the first to develop new contacts and working practices in that country, and thus providing an advantage in any further exploitation of the market. Grants provided by DANIDA so far include \$15 Million to the Indian Renewable Energy Development Agency, IREDA (WPM 1998c). Additionally, DANIDA agreed to become the supplier of funds to provide a Wind Power Systems Development and Test Centre in India as a result of the signing of a Memorandum of Understanding between India and Denmark. The objective behind construction of the centre is to promote and accelerate the utilisation of wind energy and supporting the growth of the wind sector in India. Clearly, with Danish companies dominating the Indian scene, such action is to their advantage.

Danish companies have long been active in new markets as they open, some have also begun to follow increasingly aggressive strategies internationally. This could perhaps be a response to increased competition from the turbine manufacturing industries of other nations but also of increased competition amongst the different Danish companies to seize market share of the new markets being created. Danish acquisition of other companies in order to widen their manufacturing and knowledge bases have already been mentioned.

This purchasing of other companies effectively means the purchase of both manufacturing capabilities and of skills and knowledge. It can also mean an increase in the degree of manufacturing that can be dealt with 'in-house'. That is, the increased level of mergers and acquisitions signals an increase in the level of vertical integration apparent in the remaining turbine manufacturing companies. Such an increase acts to allow companies access to a greater share of the value chain, potentially allowing greater competitiveness and thus to increased profit. It can also be regarded as an indicator of a potential shift towards a greater level of maturity within the industry.

A further strategy for Danish companies, and one that is now being mirrored by German turbine manufacturers, is to form a relationship with a company in the market to which the Danish company wishes to gain access. Danish companies have thus formed partnerships in Germany to gain greater access to that market as well as registering German based divisions of their companies. Danish companies have also been active in forming relationships with Indian and Spanish companies to gain access to the respective burgeoning markets there, with partner companies being granted a licence to produce the turbines domestically. A total of 70% of wind power capacity installed in India has been in the state of Tamil Nadu. Danish manufacturers were responsible for the sale of most of this capacity, with NEG-Micon and Vestas taking a particularly notable slice.

The Spanish market will be discussed in greater depth later but here too, Danish companies, particularly Vestas, have enjoyed considerable success in penetrating the new sector.

The result of this activity in the international market has been rapidly increasing export volume, with new annual records set each year from 1994-1998. A

total of 899.14 MW of capacity was exported in 1998, the last year for which figures are available, in addition to 316.8MW of turbine capacity sold on the Danish market in the same year (FDV 1999a). The trend seems likely to continue in the near future.

#### 4.16 Summary

As has generally been concluded by a number of previous studies, the Danish national innovation system, along with particular circumstances, has proven to be well suited to the development of a wind turbine industry. Whether it would be so suited to development of other renewable energy technology industries is not so easy to answer. It looks likely that Denmark is not likely to attempt to try to gain access to the market for photovoltaic technology, according to Energy 21 (Danish Energy and Environment Ministry 1996), its Research, Development and Demonstration programme is more likely to focus on solar thermal applications and, more recent developments suggest, wave energy.

One of the most interesting aspects of the Danish industry is how it will continue to develop in the global marketplace. Clearly there are a number of potential challenges to the dominance of Danish companies and predictably the market share of Danish companies has been dropping in recent years as competition from companies from other countries increases. Though it should be noted that a considerable fraction of this decline can be attributed to the dominance of the German market by German companies to an extent that is out of proportion with their penetration into other markets. Danish companies are however acting to maintain their advantage and are becoming increasingly active in manufacturing in other regions and countries.

The Danish Government also continues to act to assist the industry. The expressed Governmental policy of developing large-scale offshore installations should provide a continuing domestic market to continue to act as the foundation to the

Danish industry as well as helping to expand its product range and thus its market potential.

It seems apparent that the Danish turbine manufacturing industry has continued to move towards the mature phase, as defined by Karnøe in 1990. Whether this movement, and the expansion of the Danish turbine industry, will continue is dependent on a range of factors which includes the actions of the Danish companies themselves, as well as those of their competitors and the way in which the Danish companies respond to these.

#### 4.17 Discussion

##### 4.17.1 The Reproducibility of Danish Wind Energy Policy

Clearly, there are a host of reasons for the success of the Danish wind turbine manufacturing sector, some likely to be reproducible, others less so. One point that is worthy of note is that some policies will not need to be reproduced by other countries in order for development of a turbine manufacturing industry to take place. Basic work on designing the turbine concept does not need to be reproduced, for example. Some policies can be redesigned to avoid mistakes that have been previously made and to streamline the processes employed in attempting to achieve particular aims.

Cultural factors have clearly had a significant influence. The historical use of wind turbines for electricity generation has clearly played a part, including the knowledge capital that has accumulated as a result of Danish pioneering of the technology. A strong grass roots environment movement meant the placing of the technology at the forefront when alternatives were sought to less popular technologies such as nuclear. Finally, the level of commitment and experience which came with the co-operative ideals provided a framework in which the technology could find a market. The final factor in this list, ownership by individuals, either alone or within

co-operatives, quite probably influenced to a lesser extent by other cultural factors, acted to increase the awareness of the technology to some degree enabled problems relating to the acceptance of the use of the technology to be more easily avoided than has been the case in other countries, most notably the UK. Economic factors clearly aided this acceptance.

It is difficult to see how all of these factors could be easily reproduced in other countries. Clearly, it is not possible to simulate the historical experience of the Danes with the technology. Creating a grass roots movement which takes up the cause of wind technology is also not something that can easily be brought within the bounds of any devised technology policy. The uptake of the use of co-operatives for wind energy may also not have been so prevalent in most other countries, but this does not mean that something of similar model can not be introduced as a form of support mechanism. There have been small-scale attempts to introduce wind turbine co-operatives in the UK and these have met with some success, though this is yet to be applied on any significant scale. Toke (Toke 1999) goes as far as to suggest that community ownership may be the only way forward for wind power to gain a foothold in the UK, though his argument seems to rely on an analysis of the success of the co-operative system of turbine ownership in Denmark and Germany and the extrapolation of this example to suggest that it is the only way to successfully induce the acceptance of the technology in the public domain. It ignores the successful penetration of the technology in other countries, particularly failing to consider the rapid expansion of wind in Spain, even though it should be noted that one of the major Spanish manufacturers, Ecotècnia, forms a part of the Mondragon Corporacion Cooperativa. It also ignores the continued expansion of wind turbines in Denmark in

the period 1995-1999 in which co-operatives played a much more marginal part, as shown in Figure 4.1 (Morthorst 1999).

With regard to Denmark's distinction as being the home of many of the pioneers in the development of wind turbine technology, such a factor is clearly not a reproducible phenomenon. However it is not necessary that it should be. The general concepts behind the use of the technology are widely known. What is more difficult to reproduce is the in-depth knowledge base that the advantage of being the early and the continued leaders in the use of the technology offers. Clearly any nation wishing to develop an industry is going to have to invest in both R&D in the field, and in the training and education of staff with appropriate specialist knowledge, with the specific interests of the private sector reinforcing both of these areas to their own ends.

A perhaps less reproducible factor is the championing of the technology by Danish pressure groups campaigning against the use of the nuclear energy on the grounds of both safety and, to a lesser extent, the centralised nature of Danish electricity supply. Clearly, motivating sections of the population to take up a particular cause is not an easy task.

Perhaps the key factor in continued Danish dominance of the field is the continued efforts to keep the industry ahead of its competitors, contiguous with Danish companies having seized what was effectively the first mover advantage in the sector. Whilst there were actors from other countries involved in the industry from roughly the same time the key companies in the Danish sector began to operate, each was eventually eliminated following the collapse of the Californian market. This leads to what is potentially one of the most important factors in the success of Danish industry in the wind turbine sector, that is, the willingness of the Danish Government to interact and co-operate with the industry itself.



Øster and Jacobsen (Øster and Jacobsen 1990) record that, from as early as 1981, the Danish Ministry of Energy had co-ordinated with the Ministry of Industry, via the National Agency of Industry and Trade, to more easily enable the passage of technology from the R&D phase to economic exploitation. The Agency particularly focussed on the potential benefits for small companies, and indeed it is companies that started small that have enjoyed success both domestically, and as they expanded to take in the international market.

Perhaps an example of the bridging of the gap between directed Government policy and one of the cultural factors that was important in the growth of wind turbine technology and its exploitation, was the important role played by customer protection mechanisms such as the setting of standards. During the emergent phase of the industry, effectively whilst the technology was only being purchased by early adopters, another element of the grass roots origins of both the manufacturers and of the purchasers of the technology was to produce an effective form of standard setting deriving from the word-of-mouth nature of the then industry. This was then reinforced by the actions of the government mandated test centre at Risø to provide certification of turbines as the industry became more established.

Whilst it is not foreseeable that the mode of growth of a standardisation system as it developed in Denmark would be likely to grow in another context, the level of maturity of the industry, and the level at which companies would need to operate to survive mean that it is no longer necessary for a system of certification to have come from such origins. Simple setting of standards through more official channels should suffice to regulate the quality of equipment produced in companies coming from new sources, or wishing to sell in new markets. The Indian experience, for example, has been to work with the Danish test centre to provide a set of standards

for operation within the sub-continent. Producing accreditation following a similar pattern should be easily achievable for those opening their markets for exploitation. Many of the systems and components of wind turbines can be tested under the Danish system by operators outside Denmark itself, there are presently a number of facilities in Germany, and it would, in theory, be possible to issue certification for some aspects of turbine accreditation from new facilities in whichever locale could be economically justified by the volume of goods they expected to have to deal with. However, the Danish certification for the testing of systems and concepts and for blade testing can only be carried out in Risø. Thus another country wishing to apply standards, and this is likely to be a necessity if a competitive industry is to be founded would have to establish a testing centre of its own.

Whilst there is no need for nations wishing to encourage their own domestic wind turbine manufacturing industries to try to mimic the initial methods for providing publicised customer feedback, there may be the potential for similar mechanisms to have an impact in with regard to other less mature technologies and industries.

The role of the Risø test station was also important as both an R&D centre and as a focus for the increasing formalisation of knowledge that had been acquired from the 'learning through using' process. The first of these aspects should be easily reproducible, the second may not be that necessary as the learning process is unlikely to start on quite the same level of informality that formed the basis of initial Danish efforts.

The involvement of the Danish Government in R&D has also been significant, whilst duplicating some of the mistakes of others regarding research into large scale turbines initially, the Government was responsive to the greater success, and the

popular uptake, of smaller machines. Probably as a reflection of its close ties with the industry, the Government agreement with the utilities for the installation of 100MW of capacity in the period 1988-1990 saw a range of different turbines into use, so that important lessons could be learned about performance across a range of specifications.

As regards the basic research, new entrants to the field are obviously going to start at a more advanced state than the Danes had too when they started, although obviously they will start from a position behind the market leader, which was not a factor influencing Danish development. Most recent entrants do so with variations on what has become known as the 'Danish concept' as their basic model. The maturing nature of the present industry tends to suggest that innovations will continue to become less likely (Low and Abrahamson 1997) due to the costs associated with them in comparison to reduced margins for profit. Nevertheless new entrants will need to consider extensive efforts in R&D in order to be able to bring to market a product which is capable of achieving production costs comparable to the presently existing models.

The role of Small and Medium Enterprises (SME's) in the development of R&D also seems to have been significant in the development of the Danish wind turbine industry. Clearly, the grass roots origins of the technology is more in line with enterprises of a smaller nature, and the approach to learning-by-doing which was relevant to the development of the technology is one that is more easily characterised by SME's. In terms of transferring characteristics of the Danish development into the realm of other RET's, there seems to be some indication, at least with regard to some of the RET's that similar results could be achieved through an approach which allows SME's to work closely with government to achieve some co-ordination of R&D

whilst allowing smaller investors to bear risks that major companies regard as too trivial to initially be of interest. This can be related to the comments of Yeager (Yeager 1998) as discussed in chapter three, and relating to the need for increased spending on energy R&D if pure research is to stay ahead of technological development, and thereby provide it with the fuelstuff necessary to sustain it.

Naturally, the role of the Government in providing legislation, or other forms of support, to aid in the removal of barriers is an important one. As has been mentioned in the discussion of National Innovation Systems, some of these are more easily reproduced than others, with variance from country to country. It seems apparent that such issues as easing access to the grid network for those generating electricity from wind is a fairly simple piece of legislation, though it is one that needs to be built into developing legislation concerning electricity supply generally. In Europe presently, this tends to mean legislation regarding the increased liberalisation of supply.

Another key aspect of the legislation introduced to facilitate the growth of wind energy was that granting access to the grid network. Alongside the legislation which established the REFIT mechanism, the government acted to regulate the amount that wind generators could be charged to connect to the national grid. This was particularly important in the early days of development as it operated to prevent utilities from delaying the use of new technology of which they did not approve. This has presented a problem in a number of other countries. Clearly, there should not be any real barriers to introducing a policy on the same lines in any other country, though it is possible that political difficulties might arise regarding the issue in some deregulated or deregulating markets.

The Danish Government, as has been noted, has also not been shy in providing economic support for the turbine industry, and to maintain the essential Danish domestic market for turbines. The advantage of this is that as the industry has grown, it has effectively driven into place a form of circular reinforcement wherein it would now be difficult for the Government to withdraw support, were this could cause the diminution, or even destruction, of the industry. Rather than simply offering the potential for a desirable, reasonably high-tech industry to be exploited by Danish industry, the movement of the world market and of the world industry towards increased maturity means the opportunity for a significant return on investment, and thus further investment is politically expedient to secure this. The political desire to maintain employment levels also acts to provide a positive influence on the government.

Clearly, these are the benefits of having heavily invested in wind turbine technology and its use so far, stemming from the knowledge and experience in the field that Danish actors have already accumulated. Important lessons that can be learned though, are the focus on the importance of establishing a domestic market, and the application of policies that best enable domestic companies to be the ones that exploit it, rather than for this exploitation to be carried out by their competitors. This is essentially a two part policy, the first introduces measures – economic and otherwise – to create a market, and the second establishes practice which allows one's own companies preferred access to that market. There is a third part, that of supporting one's industry internationally, but this requires that the first two parts are achieved, and thus will be considered separately.

The stimulation of the Danish domestic market has been pursued through the implementation of a range of policies as have been detailed above. This had included

the use of a number of subsidy programmes as well as obligations placed on utilities to construct wind turbines, most notably in the period 1986-1988 following the collapse of the Californian market.

Central to the continued growth of wind turbine usage in Denmark has been the choice of the main subsidy scheme used to stimulate the growth of the market. From 1992 until the end of 1999, Denmark employed a Renewable Energy Feed-In Tariff as the central support mechanism for renewable expansion. The central effect of this mechanism was to provide a subsidy to all those who can produce electricity from specified renewable sources, thus allowing previously uneconomic schemes to present a profitable opportunity. The mechanism does not have the direct aim of reducing the overall cost of generating electricity from wind directly, merely of creating a market, and increased market opportunity. It is possible that the overall effect might be to reduce the total costs due to eventual economies of scale. The effect has clearly been to drive an almost continuous expansion of the technology in Denmark. The mechanism is also very much a transferable policy strand. It has already been adopted over an extended period in a range of countries throughout Europe, often with considerable success, and most notably in Spain and Germany. This does not mean, however that it would be possible to adopt the mechanism in every other country. There are political considerations to be taken into account, as well as other developments, deregulation of electricity supply being the most notable example, that have the potential to make its adoption in some areas quite difficult. This is not to suggest that it would not be possible to refine the mechanism for use within other innovation systems.

The replacement for REFIT, the RPS mechanism, has yet to prove itself in Denmark. Between the introduction of the RPS at the beginning of 2000, and until

the end of August 2000, no new contracts for the purchase of turbines within Denmark were made. As has been described, the system for trading certificates earned within the RPS mechanism had yet to be finalised, and trading was not set to begin until 2002. The RPS though would seem to be regarded as the most likely mechanism to be introduced if the EU countries agree on a harmonised model for encouraging the use of renewables. It is also much less likely than the REFIT model to face pressures from the European Union to limit subsidy payments, as it seems is increasingly likely to happen with regard to REFIT (Hinsch 2000b). The RPS mechanism seems likely to fit more easily with liberalised markets and the political philosophy that goes with them, thus it may be more likely to be favoured by those countries which have been at the vanguard of liberalisation rather than those that have lagged.

The main reason for the stagnation of turbine expansion that has resulted from the switch to the RPS stems from the increased perception of insecurity in the industry by potential investors. As with any business venture, the perception of risk in comparison to the rate of return is the key issue in determining the costs associated with obtaining capital, and thus is the key factor in determining whether a project is economically viable or otherwise.

Economic measures are not the only step involved in driving the continued existence of a domestic market. Denmark's approach to the issue of siting has been to act to try to minimise environmental impacts, particularly with regard to visual amenity, whilst also maximising generation opportunities. This has essentially been achieved through two strands. The first by passing legislation allowing economic interests to the general populace, especially those living in the locality of turbines, thus reducing the likelihood of local opposition. The second has been to place strict

limits on where it is possible to erect turbines and to identify the potential in those areas which were not under any conservation embargo. The result has been to minimise opposition and to maximise the identification and exploitation of sites. A further benefit has been the avoidance of costs associated with the development of projects that are rejected at the planning stage.

This chapter has purposefully avoided detailing the Danish national financial system in any great depth. The ground has been covered in some depth by Mitchell; repetition and any thing but an extensive attempt at updating this would be misplaced.

What is perhaps most interesting about the Danish domestic market is the total dominance that Danish companies enjoy within it. There are a number of reasons for this. The first is probably the continued benefit of the first mover advantage gained by the Danish manufacturers, this, bolstered by the relatively large number of Danish companies means that the market there is a highly competitive one. This high degree of competition means that margins are low and this acts to deter new entrants. This is reinforced by the setting of safety standards for the sale of turbines and turbine blades in Denmark, which are much more stringent than anywhere else in the world. The major economic effect of this is to drive up costs for manufacturers wishing to enter the Danish market, thus rendering them even less capable of competing with the established Danish companies. In terms of the possibility for transference, such a mechanism could easily be adopted into another nation's policy, it applies equally to all manufacturers regardless of their origin, and can be justified as being purely in place only to ensure the adequate safe performance of the technology. Thus it is unlikely to infringe either WTO or EU regulations on fair trading. The problem with the employment of such a mechanism, in terms of its use as a kind of protective tool, is that its effectiveness relies on already having an established, and possibly even



dominant industry. It might be necessary for the domestic industry to be not just established, but also already in a dominant position before such a regulation is introduced, if a situation wherein a regulation provides advantage to a non-domestic dominating industry is to be avoided. This industry will preferably already have been guided to introduce technology which already fits the technical parameters to be spelled out in the design specification regulation. Alternatively, it may be possible to choose a difference that already exists between domestic technology and that widely used by other competitors.

#### Main Points of Chapter Four

- Denmark has the most competitive domestic market place, the greatest per capita ownership of wind turbine capacity, and the most successful industry.
- Denmark has a long history of developing and using wind energy.
- Danish policy has been continuously supportive of wind energy since the oil crisis of 1979, and the Danish Government has worked closely with the industry throughout.
- There are a number of Danish policies with the potential to grant advantage to Danish companies, some of which even have effect outside Denmark.
- Denmark has derived a considerable advantage from its status as the first mover in the wind turbine manufacturing industry.

## **Chapter Five: The Development of the German Wind Energy Industry**

### **5.1 Introduction**

While Denmark continues to be the dominating nation in the wind turbine manufacturing industry, Germany is the country in which the wind energy sector shows the most activity. The rate of installation is higher than any other country and has been so for the last few years, Germany now has more capacity installed than any other country in the world. The trade magazine, Windpower Monthly, calculated that 6113MW was in place by the end of 2000 (WPM 2001). The USA, which ranked as the next highest, had a total installed capacity of approximately 2600MW. Most of this expansion has taken place in the few years since 1994 and has occurred for a number of reasons.

The German Government has invested heavily in increasing the use of wind energy and in creating a market for wind turbines. Whilst it has been at times slow to formally acknowledge that it wishes to see the creation of a German industry manufacturing turbines, it is clear from various policies that have been introduced that this is the case. As with any other country that wishes to establish itself in the international industry, if German companies are to enjoy success they require a stable domestic market in which to develop their products.

It is worth noting that in comparison with Denmark, Germany has installed a far greater capacity of turbines. In the first analysis this might appear as an indicator that Germany's commitment to wind energy goes beyond merely ensuring the existence of a domestic market for its manufacturers to service and to act as a platform for their greater penetration into the international marketplace. However, it is also possible to suggest that with German companies lagging so far behind their Danish competitors in accessing the industry they are in greater need of a larger

market in order to achieve the economies of scale necessary to close the gap on the more successful Danish companies. Nevertheless, the scale of the financial commitment that the Electricity Feed-In Law (EFL), and now the Erneuerbare Energien Gesetz (Renewable Energy Law - EEG), has required over the decade of the 1990's would suggest that a real commitment to achieving environmental gains does impinge on German policy as regards wind energy.

## 5.2 A Brief History of Wind Energy in Germany

The path followed for the development of wind turbine technology in Germany has been very different from that in Denmark. While traditional windmills were used in Germany as in the rest of Europe, experiments in using wind turbines as a source of electricity did not really begin until the experiments of Ulrich Hütter before and during the Second World War. Hütter was funded by the Nazi Party to develop methods of utilising wind energy as a possible alternative to the fossil fuels that Germany expected to have some trouble accessing during the coming war. Gipe records that Hütter completed his PhD in 1942, concluding that high efficiency and low weight were the keys to optimising turbine performance and allowing wind energy to become competitive. Gipe suggests that this conclusion was probably an extension of Hütter's previous work with gliders, where these aims are the key to improving performance. This conclusion provides perhaps an early example of the error of believing that the qualities of aircraft and wind turbines are necessarily transferable. This error was to later effect the research and development of turbines in a number of countries, where it was often assumed that turbines and planes shared similar aerodynamic qualities.

Hütter continued his experimentation following the war and developed machines based on his conclusions. In 1958 he constructed a 100kW prototype (Gipe

1995, pp78), in which the load on the blades was kept as low as possible and the aerodynamic lessons he had learned from his considerable previous experimentation were applied. Despite suffering damage on a number of occasions, the prototype was kept in operation until 1968 and gained a reputation for high efficiency. Hütter's success however was to prove damaging to German and other research efforts in the long run. His design concept was applied repeatedly in further attempts to produce bigger, more powerful machines which ultimately failed to compete with those which came about as a result of the learning based approach successful in Denmark. In the late 1970's Germany called Hütter out of retirement, most likely as a response to the oil crises but perhaps also to prevent the US from gaining too much of a lead in the technology should it prove a fruitful one. Hütter stood by his previous conclusions and these became the foundation for further German research efforts. According to Gipe, Hütter believed that the advances made in the technology since his prior efforts should enable the construction of turbines in the multi-megawatt class. Germany's efforts thus focused on these large scale turbines. The first of the turbines to be constructed under this plan was the Growian, Hütter had suggested a 1MW generator with an 80m blade diameter but was overruled by the research ministry who wished to create even larger machines. They helped to finance a 3MW turbine at a cost of \$50 million and which operated for only 420 hours in the five years from its construction in 1982 to its dismantling in 1987. Gipe describes how the failure is likely to have acted to discourage efforts by another German company to construct a single blade 5MW turbine. MAN went on to develop two smaller 'demonstration' turbines which mimicked the Danish design concept more closely but they failed to develop to market readiness.

Despite the failures, one thing is apparent from the German efforts; considerable funding was made available to support the development of the technology, at least at certain stages. The budget for renewable energy technologies first started to become respectable from around 1978, and from which point it increased dramatically.

Table 5.1 German Funding of Renewable Energy R&D 1978-1980

Year	Government Funding (million DM)	Industry funding (million DM)
1978	120	28
1979	228	30
1980	367	68

(Anderson 1995)

From 1982 onwards, however, the budget began to decline again until 1987, with a low of DM196 Million in that year. It then started to rise again, reaching DM349 Million by 1992, before again declining to what is now a fairly constant annual figure around the DM200 Million (Anderson 1995; German Federal Research Ministry 1996) and with the same amount provided annually until 2001. While the original emphasis included wind as a primary subject to receive funding, the resurgence in the provision of funds in the late 1980's, with comparatively little result at the time, reduced its importance in comparison with the other renewable energy technologies. However, as the wind energy industry became more established increases in funding have taken place, with the result that the German Ministry for Education, Science, Research and Technology's 4<sup>th</sup> Programme on Energy Research and Energy Technologies allotted DM64 Million to wind energy R&D for each year 1997-2001 (German Federal Research Ministry 1996).

In addition to the significantly higher amounts of funding ploughed into research on wind technology in comparison with Denmark, there also exists a very different underlying cultural perspective regarding environmental politics and towards renewable energy specifically. Whilst both Germany and Denmark have strong green movements, in Germany the philosophy is perhaps tied more closely to particular political parties. In Denmark a considerable renewable energy movement existed independently of the political parties, though there has been considerable political action. As has been described in Chapter Four, non-governmental actors played a large part in driving the development of wind energy in Denmark. In Germany, no significant grass roots organisation sprang up to specifically support the use of renewable energy sources, and impetus stemmed largely from the mainstream. This had a number of implications for the way in which technology was brought into use, and on the way which the industry developed.

Without any specific political constituency to support their use and funding there was no real pressure applied to accelerate the research and development of the technology. Political support tended to be cross party, with the parties predominantly committed to economic growth and to the continuation of the energy policy that was already in place, according to Anderson. The result of this was to allow those carrying out the German research programme to consider their research in the long-term. The less positive side of this is that, with no significant vested interest to support the cause of renewable energy technologies, only the inputs of the other actors in the field were considered. The German industrial model is such that research directions are frequently the product of co-operation between Government agencies, research institutes and representatives of industry. This was the case with renewable energy, and specifically with wind energy. The impact of the electricity supply

industry representatives impact was such that wind was considered largely in terms of generators that could best be fitted into the existing, heavily centralised, system of electricity supply. The effect was to further bolster the case in support of larger wind turbines, which the electricity utilities regarded as being more able to fit into their grid structure. Very little attention was paid to changing the way electricity could be supplied to users, and with no significant group with a specific wish to try and move away from a centralised system as existed in Denmark, no challenge was made to this.

### 5.3 Renewable Energy and the German Electricity Supply Industry

The relationship of the utilities to the new technologies, in addition to trying to force them into the old utility structure, was a poor one, and indeed, it can be suggested that this largely continues to be the case. The German electricity supply industry is a complex one. At the beginning of the 1990's over 900 companies were involved in generation and supply throughout the country, including eight major inter-regional companies, 65 regional supply companies and in the region of 850 municipal electricity suppliers (IEA 1998). The ownership of all of these companies is often interconnected, with the whole or part of smaller companies owned by larger ones. The utilities can be either private or publicly owned or a mixture of both. The result of all of this cross-ownership is that, as of 1994, 90% of electricity supply in Germany was under the control of the 'big eight' utilities. These companies were also, to varying degrees, partially owned by fuel suppliers and banks. Cross-directorships remain common amongst German major companies and the electricity sector has been no exception to this. Thus there are a number of important actors who have had, and continue to have, a vested interest in preventing new sources of power from gaining access to the grid. While recently more efforts have been made by the German Government to change the status quo, under pressure from the European Union (EU)

and European Commission (EC), there is still a way to go. Historically, the effects of what was a practically closed market was to place further barriers to the use of renewable energy in Germany and this acted to lessen the likelihood of a significant domestic market. This can be regarded as effectively acting to brake the growth of a domestic industry for the new technology. Problems created for new renewable projects, and for independent power producers as a whole, included difficulties in being able to arrange connection to the grid and poor prices being paid for electricity generated. The aim being to discourage the growth of new power sources by making access to the market impossible either due to lack of physical access or by making it economically difficult. Many of these problems were addressed by the Electricity Feed-In Law (EFL) and, more recently by the Erneuerbare Energien Gesetz (EEG).

Despite the close ties of the utilities to wind energy, the utilities have largely avoided becoming involved in ownership of wind generation themselves, which, it could be argued, might offer them an opportunity to recoup some of the money they pay out. This refusal might perhaps be to avoid any complications with regard to their opposition to the EFL or it may stem from a continuing preference for large-scale generation plant, or form a combination of these two factors. Nevertheless, it acts to help produce circumstances where the majority of turbines remain in the ownership of small, private investors.

#### 5.4 The German Electricity Sector

In recent years, largely due to pressure within the EU, there has been increased movement towards the opening of the electricity sector within Germany, though it has been suggested that this has been at a slower rate than has been the case in most member countries (IEA 1998; Knight 1998c). Nevertheless, the market has opened to some extent and this has a number of implications for the use of wind turbines and for



the German wind turbine industry. Legislation enacted in May 1998 introduced two concepts, Negotiated Third Party Access (nTPA) and the Single Buyer System, with the aim of allowing customers a choice concerning from whom they purchase their electricity and gas supplies. The law has already led to some changes in the German electricity supply industry, and mergers and take-overs have begun to occur. It has been suggested that the number of utilities operating in Germany will be reduced from the present level of almost 1000 to between 80 and 300 (IEA 1998). The US based Energy Information Agency (EIA) records that the six largest electricity companies have paired off, merging to form three much larger electricity producers (EIA 2000). They also record that there were a total of fifteen mergers amongst forty of the smaller municipal level generators in 1999. A trend which is likely to continue in the near future. Corporate Information, web based industrial analysts, suggest that as many as one third of all German electrical generators may have been considering a merger during 1999 (Corporate Information 1999). In theory, nTPA should allow consumers to choose to pay a 'green tariff' for electricity generated from renewable energy sources, that is, to pay a premium for electricity generated from renewable energy.

Another major factor, affecting the whole of the German energy market, is the coal industry. Coal is the only major indigenous traditional fuel source available to Germany, where both hard coal and lignite exist in large reserves. While German-sourced coal previously provided what was the cheapest source of energy available domestically, increasing environmental standards, amongst other factors, have driven up the cost such that electricity generated from German coal is roughly the same price as that of nuclear generated electricity. Reductions in the price of coal on the world market also mean that German coal costs roughly three times the world market price

and is thus uneconomical to use. The German coal industry, however, employs a significant number of people and has a powerful trade union. Its continuation is thus a serious political issue. The industry has been heavily subsidised for a considerable period of time, with the Government paying for price differences with the justification that it was in the interests of security of supply for Germany to have its own source of fuel and thus reduce its reliance on outside suppliers. The utilities were pushed into signing the 'Century Contract' to purchase German coal, originally to run from 1978 to 1987, but extended in 1981 to run to 1995. Any likelihood of it being extended further were removed when it was declared unconstitutional in 1995, at which point the government stepped in and agreed to continue to provide support, this time from the federal budget. The subsidy is provided through a levy of around 7.5-8.5%, known as the 'kohlepfennig' or 'coal-penny', on all electricity bills. The subsidy provided has been reduced markedly in recent years since the high of DM22 billion in 1992. When the source of the subsidy was switched to the federal budget in 1995, the government agreed to provide DM10 billion in 1996. It also agreed to continue to provide funding, with the amount declining to DM5.5 billion in 2005. Of this DM30 billion, DM7 billion applies only to the continued running of those parts of the industry which are to remain in operation. A further DM3.2 billion was authorised to aid the reduction in activity in the industry. The continued provision of funding to 2005 was ensured through an agreement to reduce the number of mines producing hard coal, all in the former West Germany, from nineteen to eleven or twelve, with a consummate reduction in employment from 76,000 to 52,000 miners in those pits. Those mines in East Germany producing lignite are to retain protected status until 2002. The obvious effect of the subsidisation is to give German coal an unassailable market share. This has led to objections from the coal industries of other nations,

notably the UK, though the placement of the subsidy has been upheld by the European Commission on the grounds that “it helps to solve the social and regional problems affecting the future of the German coal industry”.

The obvious implication for the wind turbine industry is that such a subsidy effectively closes off a significant part of the domestic market for electricity production and supply, so that renewable energy sources are competing in a smaller market than would otherwise be the case. It can also be argued that with the Government providing such a massive amount of subsidy to one part of the energy industry it will be more difficult to provide additional funding to subsidise the newer fuel sources.

The enforced removal of the obligation on the utilities to purchase coal in 1995 meant that the price charged directly to the consumer was reduced. This had a number of implications with regard to renewable energy usage. It effectively reduced the apparent price charged to the customer, thus making renewable sourced electricity look less attractive to the consumer, on the other hand the consumer may find that their reduced bill and increase in funds, be it apparent or real, leads to a greater interest in green energy schemes.

Essentially the German electricity market has been a very fixed one. It has had a very high level of vertical and horizontal integration as well as a high level of regulation. Though the government has begun to take steps to remove some of the barriers to accessing the market so far improvements have not gone at the speed that was initially hoped for. Continuation of this policy – in line with European Union legislation – is likely to lead to a more open market.

#### 5.5 The Electricity Feed-In Law

The actual problems of physical connection and obtaining a market were solved for renewable energy in Germany with the introduction of the Stromeinspeisungsgesetz or Electricity Feed-In Law (EFL) on January 1<sup>st</sup> 1991. This obligated German utilities to purchase all electricity offered to them from a range of renewable sources, with wind generated electricity to be paid for at a price equal to 90% of the average price charged to end-users over the year. The price was thus recalculated on an annual basis. This was an example of a 'renewable energy feed-in tariff'(REFIT), mechanism. Under the EFL each utility had an effective catchment area within which it was obliged to pay the tariff to the generators of electricity from any qualifying projects within that area. The EFL laid down that the actual connection of the generator to the grid be paid for by the project developer, with the utility responsible for arranging and financing its own affairs technically in order to be capable of utilising the electricity delivered to its grid network. The main sticking point that arose was that the utilities, opposed as they were to the law overall, submitted excessive bills for grid connection.

This problem however could very much be regarded as an adjunct to the rest of the controversy that stemmed from the EFL.

From its inception the German utilities had been opposed to the obligation placed upon them by the EFL. Wind energy, as a result of being the technology which had enjoyed the most success, bore the brunt of this opposition. This is perhaps understandable, when consideration is given to the fact that the utilities collectively paid DM400-500 million annually, in comparison with the sum they would have paid for the electricity from their preferred sources, were the law not in place (PiE 1997).

One of the main objections to the original law was that it contained no mechanism to spread the costs of its implementation. Only the utility which supplied power in the area in which a project was based was required to pay, hence the utilities in those areas where development of wind turbines was more rapid had to bear the heaviest costs. The initial expansion of wind receiving payment under the EFL was, predictably, in those areas with the best wind regime, that is, on the northern coast of the country. The two north-western Länder of Schleswig-Holstein and Niedersachsen have by far the greatest fraction of new turbines installed. There has been an increasing trend though, for sites further from the coast to be used, and the share of the number of turbines installed in the coastal areas is declining in comparison with the figure for Germany as a whole. Despite this changing trend, there remained an above average level of installed capacity in the catchment areas of utilities in the coastal areas. These utilities, and their customers, were paying to support wind energy, and it was these that led the campaign against the law. Their initial objections were based on the argument that it was unfair that they, and their customers, should have to pay, when the environmental benefits accrued to Germany as a whole. In 1992, the utility Schleswig suggested that a national levy on electricity bills, similar to the *kohlepfennig* would be a fairer approach. The 1994 decision of the German Federal Court that the *kohlepfennig*, was unconstitutional led the utilities to formalise their argument and to challenge the EFL on the grounds that it also was at odds with the constitution. They cited as grounds, that it placed an unfair burden on individuals and organisations and that it might further be illegal on the grounds that “direct state subsidies could achieve the same ends without recourse to law”. On this basis, the utilities brought a number of test cases before the federal courts. Each however was rejected on the grounds that the sums involved were too small and that the law

contained a hardship clause to protect companies from having to pay more than the company could safely manage. The courts also pointed out that the utilities had a “monopoly-like position in their demarcated supply areas and therefore carry a special responsibility to see that resources are used sparingly and that account is taken of climate and environmental protection” (Knight 1996b).

The Feed-in law has also enjoyed considerable political support, with practically all parties expressing that they would wish to see it continued in some form. The EFL was changed to some degree in 1998 to become the Erneuerbare Energien Gesetz (EEG), which has been commonly translated as the ‘Act on Granting Priority to Renewable Energy Sources’, though it literally translates as ‘Renewable Energy Law’. The change in the legislation on renewables took place at the same time as the new German legislation regarding the liberalisation of the German energy market (Mallon 2000). The EEG effectively acted to bring the EFL into line with the new legislation introduced to reform the energy sector. The immediate effect of the EEG was to place a cap on renewables, such that they may not supply more than 10% of electricity in Germany.

The beginning of the year 2000 saw the adoption of the new tariff scheme, detailed in the EEG law. The EEG effectively acts to bring the original EFL legislation up-to-date, to widen its scope, and to try to remove any of the problems that the EFL engendered. The EEG lays down pricing mechanisms for the support of a range of renewable energy technologies, most relevantly to this research, it redefines the regulations regarding the financial and institutional support of wind energy.

The EEG law restates the obligation to grid owners regarding connection of renewable energy generators to the grid where such a connection is requested. The nearest grid owners to a proposed site are obliged to connect a new generator to their

grid. Whilst the generator owner is liable for the costs of connection to the grid, the bill submitted to the generator for this function is made subject to oversight to ensure that the cost is a reasonable reflection of the actual costs. The grid owner is liable for any costs relating to the upgrading of the grid to facilitate the new generator.

The EEG Act compels the grid owners to then purchase the electricity produced by the renewable energy generator within the pricing mechanism laid down within the Act. These additional costs may be passed on to upstream grid owners, utilities and to the eventual consumer.

The new act also contains provision to address one of the most contentious aspects of the old EFL Act, establishing a national equalisation scheme. This removes the iniquitous system set up under the EFL, whereby the costs borne by the utilities, which had to accept the electricity from projects established in their catchment areas, could only be passed on to their own consumers. The national equalisation scheme provides a mechanism for, and makes compulsory, the payment of compensation to those transmission grid owners and utilities which bear above average costs of paying for renewable energy sources from those which make purchases below the average. The amounts needed for equalisation are calculated annually and paid off in monthly divisions.

This change may have a number of implications for wind energy in Germany. It should act to remove one of the central objections made by the utilities which have previously had to bear the brunt of the compulsory payments due purely to their location. It removes one of the central legal arguments for the removal of the EFL mechanism. The equalisation, and its effect of distributing costs across all consumers, may also enable the support mechanism to appear less objectionable to the European

Commission (EC) and its Competition Directorate (DG IV), and thus less likely to be restricted or limited by the EC.

Interestingly, the law also changes the mechanism for calculating the base price paid for wind generated electricity. The previous flat payment of 90% of the final consumer tariff is replaced by initial payments of 17.8 pf/kWh for the first five years, with the potential for an extension of this period dependent on the actual performance of the turbine. This extension is calculated according to an equation wherein the higher payment continues to be paid on the basis of a figure for 150% yield of a given turbine, and extending the higher payment period by two months for every 0.75% that the turbine falls short of this yield. This has the effect of producing a scale of payment dependent on the quality of the location of the wind turbine and, it is hoped, ensuring that efficiently operated turbines can be run profitably, while inefficiently run turbines can not. The effects of this may well be an increase in the number of sites that can be profitably operated, and, it is speculated, may act to increase the further penetration of turbines to sites further from the coast. Regardless of when the higher payments cease, the turbines should, at least in theory, continue to be paid at a rate of 12.1pf/kWh for a minimum period of twenty years. Whilst the lower rate is below that paid under the old EFL mechanism, which had dropped to 16.1pf/kWh by early 2000, the initial higher rate obviously exceeds it significantly. This approach should act to provide more of a return during the early stages of turbine operation, thus aiding in obtaining capital. It should also provide increased security with regard to another approaching problem regarding the tariff paid under the original EFL dropping too low to be economic. Whilst the figure of 90% of the final customer price laid down by the EFL was easily sufficient when introduced, the price of electricity declined through the late 1990's to the 16.1pf/kWh mentioned above.



This downward trend is predicted to continue, with some commentators predicting price reductions as substantial as 30-40% (CorporateInformation 1999). Using the old EFL 90% figure would have meant a reduction in the tariff paid to renewables to the point where it may have been too low to support the continued expansion of wind energy in Germany.

The EEG also draws offshore wind projects in to the payment mechanism specifically, placing support for offshore installations alongside onshore projects, but with the initial rate of 17.8pfg/kWh available for the first nine years of operation. It would appear that the nearest grid owners to offshore installations will be compelled to provide connection to the national grid, as with onshore installations (EEG 2000). Though, as with onshore, they will be reimbursed for costs under the equalisation provision of the EEG.

The results of the new law seem to have been positive so far in Germany and orders for new turbines have continued to be made throughout 2000, in direct contrast to the situation in Denmark since that country introduced its own new mechanism for the subsidisation of wind energy.

Turbines which are already in operation will also switch to the new tariff scheme, though with an amendment to reflect their status as already having received some subsidy. "Half of the period for which turbines have operated up to April 1, the day the law kicks into effect, is knocked off the period calculated for the highest payment rate. To protect owners whose turbines – because of their age – no longer qualify for the higher rate, all turbines in operation before April 1, 2000, are guaranteed DEM 0.178/kWh for at least four years." (Knight 2000b)

However, the utilities have not given up their opposition to the German REFIT mechanism, despite the changes in the instrument from the EFL to the EEG. They

also enjoy a certain degree of support for their protests against the REFIT, in either of its forms, though the EEG has caused some changes to the way their case is perceived. In 1996, the then European Commissioner for competition issues, Karel van Miert, is reported to have demanded a reduction in the rate of the EFL. The EFL had originally been approved by the European Commission when proposed in 1990, on the grounds that it was a scheme aimed at protecting the environment and, in addition, appeared to suggest only a very small scale was intended and that this could not be regarded as a threat to other methods of generation. The large-scale success of the legislation led to a rethink on the part of the Commission and to a request for a rate reduction from 90% to 75% of the average final customer price (Knight 1996a). The Commission report also suggested that the subsidy should be available for a fixed, specified amount of time rather than indefinitely as was the case with the EFL, and that the rate paid should decline over this fixed period.

The wind energy sector responded to the Commission's by producing three reports claiming that any reduction in the level of subsidy could bankrupt a number of medium-sized companies. One of the wind energy associations, Bundesverband Windenergie (BWE) producing a report claiming that a reduction of even 1pfg/kWh could lead to a collapse of the market (Knight 1997a). Naturally, all of these organisations had vested interests in the continued availability of the larger payments.

The Social Democrats have long expressed a desire to phase out the use of nuclear power in Germany, and now in government, have committed to phase out nuclear power altogether. Clearly, this would have significant implications for all aspects of German energy supply, including renewable energy. Whether it is likely to actually occur, and if so on what time-scale, remains to be seen. The CDU/CSU

coalition which was removed from power as a result of the 1998 election has expressed concern that the high rate available to wind, 17 pfg/kWh at the time, was liable to “lead to excessive support for wind energy in coastal areas and the use of wind at unsuitable locations in inland areas” (PiE 1997) and had proposed a series of reductions in the rate over the period 1998-2000. Obviously the introduction of the EEG has changed the nature of the interaction of all the government, industrial and environmental actors

BWE have also suggested that the 5% cap placed by the EEG may be contrary to a European Directive on the Internal Energy market (Knight 1997b) which came into force from February 1999 and should act to preclude the emplacement of ‘hierarchies of supply’. This, in theory, would prevent limitation being placed on any part of the energy sector. Whether a highly subsidised sector would remain able to justify its subsidy legally however, would seem questionable in an EU-directed liberalised marketplace. This remains true given the comments of Commissioner Van Miert, and those of his successor, Commissioner Monti regarding the relevance of the subsidy.

Danish plans to introduce an RPS mechanism to replace its original REFIT mechanism were not passed into legislation nationally until the approval of the EC had been given that they it would not contravene EU rules regarding the application of state aid. The German Government did not submit plans for the EEG to the EC, claiming that it was not a form of state aid as the tariff is generated through a premium to consumers rather than from state funds. The EC suggested that notification of the application of the policy should be made a priority, in order that the EC might more rapidly adjudge the legality of the mechanism within EU rules on state aid for environmental protection, and that the premiums would not place an

unnecessary burden on consumers. The March 2001 ruling by the ECJ that the old EFL mechanism was legal (Knight 2001) will probably mean that challenges to the EEG will be dropped for the present due to the similarities between the two systems.

The result of the problems with the EC was the creation of uncertainty regarding the future of the EEG, and the undermining of the long term confidence that the extended payments were intended to engender, and which is essential to encouraging investors in the industry.

The alterations to the REFIT legislation may help to clarify a number of issues stemming from the fact that the original law applied within the context of the monopoly position of the utilities. Continuing liberalisation means that this monopoly is, at least in theory, no longer strictly applicable. The amendments to the law account for this and upholds the obligation to 'utilities that operate a supply grid for the public'. The Commissioner suggested in late 1998 that the changes made to the REFIT to unify it with the Energy Industry Law were not sufficient to enable the REFIT to fit within the context of the EU's Internal Energy Market (Knight 1998a). Van Miert indicated that the law would require the insertion of further codicils limiting the payment of the subsidy to a fixed period and to a fixed volume of electricity generated, in addition to a gradual decline in the level paid before the Commission could re-approve it. The EC opposes the use of REFIT mechanisms generally due to the lack of competition inherent in their use. However, a recent court case may mean their opposition will fail to end the use of such mechanisms. In 1998, the German utility PreussenElektra made a complaint against the original EFL legislation on the grounds that it broke EU regulations concerning state aid. The German court considering the case referred it to the European Court of Justice (ECJ). The ECJ ruled in early 2001 that the mechanism was legal, and that the REFIT as

applied in Germany does not amount to a state subsidy. This ruling has important implications for the use of the mechanism in the EU. EC opposition to the use of the REFIT mechanism is effectively undermined by the decision and the use of the REFIT will be able to continue both in Germany and in the other countries which employ it in the EU, such as Spain, and those countries which are set to use it, such as France (Renew 2001). Further problems may arise however, should the mechanism run afoul of later EU legislation relating to the internal market for electricity.

Despite the controversy that has arisen from it, the EFL and its amendments have undoubtedly been a major factor in encouraging the growth of wind energy in Germany. By acting to create a domestic market, they have significantly contributed to the provision of a base for the development of a German wind turbine manufacturing industry. A number of other factors have been relevant in allowing German companies to exploit that market to the extent that they do.

#### 5.6 Other sources of Funding for German Wind Energy

In terms of enabling the crossover of the technology from research into commercial exploitation, Germany was quite slow, with significant expansion of wind not occurring until the beginning of the 1990's. A 1990 programme to develop, install and test 250 MW coincided with increases in the amount of electricity generated from wind in Germany from 26.1GWh in 1989 to 121GWh in 1990 and 215GWh by 1991 (Eurostat1995), since this point it has increased substantially each year. The original 250MW programme (itself an extension of an earlier 100MW programme) provided an additional operating subsidy of 6pfg/kWh on top of the EFL mandated price, at the time equal to 16.52pfg/kWh. The resulting 22.52pfg/kWh available was thus very substantial, Anderson for example makes a comparison with the rates of around 9-10pfg/kWh that were available to American projects at the time

and with which they were able to operate profitably. The result was that the programme was heavily oversubscribed. Anderson suggests that by applying a lower level of remuneration, considerably more capacity could have been incentivised without any greater cost having to be borne by the taxpayer. Anderson also posits the possibility that the Bundes Ministerium für Forschung und Technologie (BMFT), the ministry with responsibility for instigating the programme, may have been influenced by the utilities to class the programme in terms of a pilot programme rather than as out-and-out commercialisation. The programme was originally intended to monitor the equipment used over a ten-year period and thus had the potential to act as a brake on the development and expansion of the use of the technology. However this monitoring programme, and the slow pace it engendered, has been superseded by further policy developments which have made it considerably easier for growth in the sector. It is also worth mentioning Anderson's suggestion that the high level of subsidy may have met with the approval of the utilities in order that wind energy appeared to be expensive in the eyes of the public, particularly in comparison with the nuclear and gas-burning power stations that the utilities preferred.

Whatever the motivations, the '250MW programme' was very successful in attracting investment – and investors – into wind energy projects. Various other policy initiatives have acted to further support the growth and expansion of wind energy generation and of the German wind turbine manufacturing industry. Gipe, in his book, *Wind Energy Comes of Age*, represents Uwe Cartensen of the German Wind Energy Association, Deutsche Gesellschaft für Windenergie (DGW) as suggesting that the subsidy from the BMFT was directed to projects such that German turbine manufacturers were favoured. He points out that over two-thirds of the subsidy funding went to projects using German built turbines. While the application

of the EFL meant that any turbine constructed was eligible, Government control over the BMFT subsidy meant more careful targeting of funds was possible and that money could be directed towards a number of small German turbine manufacturing companies. Judicious use of the smaller subsidy meant that considerable amounts of the larger subsidy went to German interests.

The '250MW programme' was discontinued in 1993 and the subsidy withdrawn. Gipe also represents Cartensen as suggesting that the German Government would like to see some degree of market protection maintained but with the main goal of such a policy being to support the growth of renewables for their own sake rather than in order to encourage the growth of a new industry. While development down this path would be quite interesting in itself, it is however unlikely that Germany would refuse to act as a base for the future growth of the industry should the opportunity be available.

A further substantial source of financial support for renewable energy, and particularly wind energy, projects comes in the form of 'soft' loans. The major source of such loans is the Deutsche AusgleichsBank (DtA). The DtA is a 'wholly-owned development agency of the German federal government'(DtA 1998) . With respect to renewable energy, the DtA offers loans through the Environment and Energy Saving Programme of the European Recovery Programme (ERP) for which it is responsible, as well as from the DtA's own environment programme. The DtA claims to have provided almost DM1.2 billion to renewable energy source projects in 1997 (DtA 1998), with the majority of this going to wind energy projects. This marked an increase on the amounts made available in 1996 when DM538.3 million went to wind projects from the ERP, with a further DM209 million from the DtA programme, for a total of DM747.3 million, approximately 85% of the funding available in that year

(Knight 1997c). From 1990 to 1996 a total of DM 2.47 billion was granted in loans to wind plant, with around 75% of all the turbines installed in Germany by the end of 1996 having received loans through the Bank's programmes. The loans are available at extremely favourable rates, can be held up to a period of twenty years, can include a number of interest-free years and provide credit for up to 75% of the total investment figure for businesses and 100% for private investments. The investment limits are flexible and can be ignored if a project is deemed worthy of additional funding. This relaxation has frequently being applied to wind energy projects. Developers are also permitted to apply for additional aid from regional development programmes without incurring any penalties within the loan programmes. In 1999, the DtA provided ECU1.3 billion for the promotion of wind-powered devices, an increase of 60% on 1998 (DtA 2000a; DtA 2000b). Lindley suggests that "one of the most dramatic influences that any single institution has had on Renewable Energy Development is that provided for wind energy projects by the Deutsche AusgleichsBank" (Lindley 1996).

The DtA is an instrument of the Federal Ministry of Economics. Its main roles are to act as a stimulus to the starting up of new companies and the support of the small and medium sized enterprises. The funding it provides can be directed at development projects in such a way that pressure is brought to bear in favour of German turbine manufacturers, providing advantage to them and enabling them to gain sales as with the BMFT subsidy of the early 1990's.

One aspect of Danish policy that has been helpful to the protection of the turbine manufacturing sector in that country has been the government-enforced purchasing of capacity by the electricity generating utilities. Whilst such an obligation might be useful to the German turbine manufacturers, it is effectively made



illegal under German law and, with the liberalising of the electricity market in 1998, is rendered even less likely to be used.

### 5.7 The Role of the German Regions

The federal nature of Germany means that in addition to stimuli resulting from national policy, individual Länder may act to institute policy to the benefit of their specific constituents. A number of Länder have acted to encourage the use of wind energy and other renewable energy technologies within their borders.

As has already been mentioned, the two German Länder most active in wind energy, both in terms of developing capacity and industry, are also those with the greatest wind potential, Schleswig-Holstein and Niedersachsen, both in Northwest Germany. Both of these have made long-term commitments to the development of wind energy, each fixing a target of 1000MW capacity, Niedersachsen by 2000, Schleswig-Holstein by 2010. Whilst Schleswig-Holstein originally led the way in terms of capacity installed, with 630.8MW on-line by the end of 1997 (Knight 1998b), compared with 565.2 MW in Lower Saxony, a greater amount was installed in Lower Saxony than in Schleswig-Holstein in 1997. The continued greater installation rate on the part of Lower Saxony meant that by the end of 2000, that Länder had an installed capacity of 1290 MW, compared with a figure of 1000 MW for Schleswig-Holstein (WPM 2000a). These figures place both Länder in excess of their original targets.

The capacity installed in either of these two Länder greatly exceeds that in any of the other Länder. Schleswig-Holstein is advantaged by having the better wind resources and has further built on this since 1988, when a new regional Government came into power with the stated view that wind power could serve as an alternative to the nuclear power they wished to see phased out. To this end, they introduced

investment grants of up to 30% of plant capital costs in 1990, a year before the EFL came into use and while the BMFT subsidy programme was already running. This additional subsidy helped to create a 'boom' atmosphere in a similar way, though on a smaller scale, to that which additional subsidy provided by the Californian legislature created a boom there in the early 1980's, when added to nationally provided tax breaks. This German boom encouraged the creation of a number of new manufacturing companies to service the market for those wishing to enter the wind generation market.

A further stimulus was the founding of the Investitionsbank Schleswig-Holstein in 1991. The bank was created to run a number of Government programmes, including that regarding wind energy, and to act as an investment bank for the region (Rave 1998). The IB is a non-profit organisation which acts to advise local government, investors and turbine manufacturers, and to co-ordinate federal and regional incentive programmes. A total of ECU85 million was directed to wind energy through the bank's efforts in the period 1990-1997, resulting in projects with a total investment of ECU1 billion in the region. As an indicator of the role of the bank in the development of wind energy, it is worthwhile to note that Klaus Rave, the President of the European Wind Energy Association (EWEA), is also a managing director of the IB (Aubrey 2001).

Schleswig-Holstein has also provided support for the nascent industries in overseas markets, co-sponsoring trade fairs in India (Mathews 1995) and trade missions in Indonesia and Vietnam (Knight 1995) to promote its manufacturers of wind energy technology and other renewable energy technologies. As with the majority of turbine purchasing markets, Germany is already far behind Denmark in

sales to the Indian market, though sales are growing due to expansion by the German company Südwind.

Lower Saxony has also acted to encourage the growth of its own turbine manufacturers, they have also offered capital subsidies on top of nationally available subsidies to encourage greater use of turbines, allowing the region to rapidly expand its wind energy capacity.

### 5.8 Planning Issues

The growth of wind has been very rapid in Germany and this has led to increasing opposition to siting of turbines. Problems have been exacerbated by the lack of regulations applicable to the installation of turbines in rural locations. The Government has responded to this by strengthening planning guidelines to some extent and has introduced strict regulations restricting the areas in which turbines may be located. Essentially, a federal law introduced in 1996 established that once a municipality has developed a zoning plan for its area, it must approve any application to establish wind energy generation provided no public interest issues apply. Whilst it is possible to interpret these new regulations as having some similarities to the restrictive nature of planning for wind turbines in the UK, in practice the German regulations remain far more liberal. It is perhaps also possible to suggest that some minimum level of restriction might actually help rather than hinder future installation by preventing the completely unregulated spread of turbines into all areas it might have the potential to deter an eventual backlash, and consumer and political disfavour. The continued growth of the sector in Germany would seem to suggest that the regulations have not been overly restrictive. By the end of 1999 it was planned that the whole of Schleswig-Holstein will have been assessed for the appropriateness of wind turbine siting and all areas suitable for development classified as such (Rave

1998). Toke records that permits for 3000MW of wind turbine projects were available by 1999 (Toke 1999).

### 5.9 The German Wind Turbine Manufacturing Industry

From a late start in comparison with Denmark, the German turbine manufacturing industry had grown to be the second largest in the world by 1997 (FDV 1999). This growth can largely be ascribed to the existence of the domestic market that has come about as a direct result of Government policy as described above. Where the industry remains weak however, is in gaining access to markets outside Germany. Internationally, Denmark's industry continues to dominate the marketplace to a very large extent. In 1997 German companies sold only 157 machines outside their national market, with a combined capacity of 53.78 MW (Knight 1998d). This figure has been rising annually, exports amounted to 125.8 MW in 1998, a 130% increase on the previous year, but still only equal to 15.9% of the total capacity installed in Germany in that year.

The largest of the German manufacturers, by a considerable margin, is Enercon. The company has dominated the German marketplace since 1990, outstripping even Danish competitors, and typically capturing 30-40% of the domestic market.

The company was founded by Aloys Wobben in 1984, that is, a few years after most of the presently successful Danish companies entered the market. Whilst imitating the basics of the 'Danish concept' for wind turbines, Enercon also introduced some innovations of its own - the most notable being the introduction of pitch regulation and of gearless turbines. The company is also noteworthy for carrying out the manufacture of all its components on an in-house basis, as well as carrying out independent R&D. Whilst Enercon outdo all other companies in

Germany, and generally export a greater fraction of their turbines than other German companies, they have experienced difficulty in competing with Danish companies in other markets. They appear to have attempted to focus their efforts in countries where Danish companies are not yet established, which makes sense but has perhaps meant that they have foregone accessing some large markets such as Spain. Enercon have had operational manufacturing facilities in India since 1994, and in Brazil since 1997. Enercon have also experienced difficulties in accessing the US. The use of its variable speed technology is banned from sale there until 2011 following a patent dispute with an American company, effectively preventing the company from selling its goods there until then.

A number of other German companies of smaller size also exist, each also struggling to expand its operations outside its domestic base. Nordex, a German/Danish founded in 1985 is unusual in that its Danish part ownership and manufacturing facilities give it some access to the Danish market, which should, at least in theory help to make it more competitive outside that market.

Tacke Windenergie was the second largest of the German manufacturers until its 1997 bankruptcy led to its purchase by the American Zond turbine manufacturing company, as a foothold to the European market, and subsequent incorporation into the US parent company of Enron.

Despite some success in capturing a share of the again expanding Indian market by Südwind and by Enercon, Danish companies continue to dominate there. More worryingly for the industry, German companies have been slow to capture significant portions of the new, and rapidly expanding, Spanish market. In 1997, 262 MW of capacity were installed in Spain. Half of this capacity was manufactured by Danish companies, none was manufactured by German companies (WPM 1998). As

of 2000, the German market leader, Enercon, continued to have poor market penetration in Spain, though the much smaller German interest, Fuhrländer, which atypically for a German company exports half of the turbines it manufactures, was establishing a Spanish subsidiary with manufacturing capabilities in Madrid.

The failure in Spain is particularly notable; as part of the European Union, access to the Spanish market is, at least in theory, unrestricted for both Denmark and Germany. Already German companies have lost any advantage they might have had over Spanish companies. Whilst no significant Spanish turbine manufacturers were operating other than on a very small scale when the market opened, this is no longer the case, and German manufacturers have generally failed to seize the opportunity this might have afforded. The fact that Danish manufacturers have responded to this, and gained a large section of the market as a result, German manufacturers seem to have been much slower to respond, and this can only be regarded as a negative sign regarding the state of the industry in Germany.

The 1997 figure which had exports accounting for just 9.2% of all capacity sold by German manufacturers, showed a drop from the healthier 24.39% figure of 1996. The German Wind Energy Institute, DEWI, accredited a substantial portion of this reduction to the bankruptcy of Tacke Windtechnik. The fraction of turbines exported has been slow to rise back to the 1996 level though, and this remains a very negative indicator concerning the hopes for German expansion outside the domestic marketplace. There are favourable indicators that matters will improve, but clearly if Germany is to be a global contender in turbine manufacture it is going to have to act to capture a much greater share of the international market to go alongside its more sheltered domestic sales. This is particularly important given the potential for limits on the size of the domestic market, from either physical limitations imposed by

availability of sites or through political pressure being brought to bear on the internal German support system at the present, and the potential for the changes in the domestic market this might bring.

To continue their existence German companies are going to have to become more competitive internationally. There is some evidence that the level of German exports is increasing, but they remain some distance behind the figures for Danish exports. DEWI, who monitor and have published a number of reports concerning the German and world wind markets, have suggested that Germany is limiting the ability of its turbine manufacturers to expand by not providing financial guarantees from outside the industry, thus forcing the manufacturers themselves to use their own capital as a guarantee. With only limited available capital, the range of projects which can be supported are severely limited and so, therefore, is the volume of business that a company can capture (Knight 1998d).

#### 5.10 The Development of the German Wind Turbine Industry in the Context of the German National Innovation System

As with Denmark, aspects of the German National Innovation System directly impact upon the development path of turbines and the German wind turbine industry, a path which is very different to that followed by the industry in Denmark.

Firstly, German efforts in wind technology centred around, and stemmed from, the efforts of the German Government. This engendered a number of implications for the development of the technology. It meant that German efforts were formalised within the structure of a Government funded R&D programme, and thus Germany essentially employed a 'top-down', science-based strategy which was to prove largely unsuccessful. It was not until German companies switched to effectively mimicking the Danish concept that machinery was produced which was

both technically useful and economically competitive. German efforts in focusing on competing in the international research arena and in terms of an assumed research goal, without, it would appear, full regard for the possible ways to reach that goal meant that considerable effort and monies were squandered. Burton and Hansen's description of Germany's technology policy suggests that such an approach could be regarded as a reflection of Germany's philosophy with regard to such research and to its own self-image (Burton and Hansen 1993). They suggest that Germany's strengths lie in mimicking the technologies of other countries and building an industry from there, rather than developing its own technologies. They suggest that German industrial policy emphasises building from the existing knowledge base rather than developing new technologies outright. It is possible to draw parallels between this philosophy and the belief that German expertise in aerodynamics and other engineering would have allowed the easy development of wind turbine technology as an extension of the existing knowledge base. The failure to appreciate that there might be significant differences between the two technologies, and that this approach might not produce the desired results, and that these might require a different approach goes some way to explain the initial German failure in the area. The theory that German industrial policy is more effective at mimicking proven technology also ties up with this theory, when consideration is given to the eventual adoption of the Danish concept as the basis for German wind energy technology.

Perhaps one of the most significant positive aspects of the German system is that it is a major world economy, it thus has the resources to put into supporting the development of a new industry with a range of financial aid instruments such as subsidies, tax breaks and soft loans. The nature of the German innovation system is structured such it was relatively easy to put into place, and apply, these support



mechanisms to the wind turbine manufacturing industry and directly supply the funds to the areas in which they were needed. The German national financial system has a number of aspects which are suited to the encouragement of smaller enterprises as detailed by Mitchell (Mitchell 1994), including the investment banks specifically suited to the needs of companies at that level, as detailed above.

The subsystems of the German national innovation system relating to market and industry are also relevant to the way in which the German domestic market has developed. A number of financing groups employing a structure similar to the Danish method of using co-operatives has manifested, and by 1998 the European Wind Energy Association (EWEA) estimated that around 100,000 Germans had invested in wind turbines in Germany (Aubrey 1998), a number roughly equivalent to those investing in turbines in Denmark, though forming a far smaller proportion of the general population. The EWEA suggests that investors come from a range of backgrounds, including farmers and co-operatives, and have a selection of motivations, including both profit and a desire to see environmental improvements. One effect of the guaranteed sales provided by the EFL is to increase confidence in the viability of turbine projects and to allow small investors like these to be able to take the thus much lessened risk. A corollary of this is that wind turbines have become more generally acceptable in Germany than might otherwise be the case, and have gained a constituency with an interest in their continuing support. The EWEA reports though, that an organisation has arisen to oppose the growth of turbine usage and siting in the Germany. Whether this group will actually have any significant effect on the expansion of wind exploitation remains to be seen.

The position of those entering the German turbine manufacturing industry is also an interesting one. Germany has a culture that includes businesses across the full

range of sizes, up to major multi-national companies (MNC's), and several of the German MNC's have an interest in industrial development of photovoltaic technology. The companies which are involved in the German wind turbine manufacturing industry have tended to be smaller. Though more recently there has been some investment on the part of large scale companies, large companies have been reticent becoming directly involved in the sector. While it has been suggested that this general avoidance of involvement with wind turbine manufacturing may be to avoid conflicting with the operations of such subsidiaries where they exist, many of the large engineering companies which would seem to be the obvious candidates to attempt to gain access to the industry, seem to baulk at any manufacturing for wind turbines beyond the level of components. It is possible that this reticence is related to the expensive failure of those large companies involved in the attempted development of large turbines in the initial German research effort of the 1980's. If so, their absence can be regarded as another consequence of the ill-chosen top-down strategy utilised at that juncture. The reasons for the choice of this route have already been discussed to some extent, that is, that Germany wished to compete with the US for the development of the technology and thus followed the path that the US had already chosen for its own efforts in the field. It is also possible that Germany regarded the new technology as something that it would wish to produce on a large scale, should it prove successful. The work on the new technology was thus assigned to large companies, those judged to be capable of large-scale production capacity should the need arise. That is, it is possible that the German authorities had an industrial philosophy in place which acted to limit the choices which they allowed themselves, effectively reducing the options available.

Germany can also be regarded as the nation which is the most significant example of private-sector governance (PSG). PSG is a form of governed interdependence which Weiss describes as “a system of state-informed co-ordination in which the state acts as co-ordinator of ‘last resort’” (Weiss 1998, pp.70), qualifying this by pointing out the “prevalence of private initiative in public policy”. Weiss also points out the way in which the German State has historically acted in order to compete internationally through the mobilisation of large amounts of capital by creating publicly funded financial institutions (Weiss 1998, pp.120). This method has been utilised since the late 1800’s and through the early 1900’s (Wever and Allen 1993), and while the institutions thus created are no longer necessarily in the public sector they formed an important part of the post-war regulatory structure. Wever and Allen suggest that despite this, such ‘organised finance capitalism’ continues to exert considerable influence over German industry and that the results include a preference for ‘long term investment, the presence of the banks on company boards, and the inter-penetration among leaders of industry and finance’. This has a number of implications for the development of the turbine industry. Firstly, while Weiss points out that PSG is highly effective in establishing German industry in markets for ‘highly engineered quality goods in which innovation has been presumed within an already established technological paradigm’, she suggests that it is less able to respond to those changes which require development of new technology. Both Soskice and Porter back this up with empirical evidence which highlights German strengths in incremental innovation in the developing of established technology and corresponding weakness in coming up with radical new technologies (Porter 1990; Soskice 1997), a point which has already been discussed here with regard to the work of Burton and Hansen (Burton and Hansen 1993). Effectively this means that PSG

can have the effect of acting to cause German industry to behave in a relatively conservative manner. This factor may also tie up with the failure of German industry to achieve success in the early, emergent phase of the wind turbine manufacturing industry, and with the comparatively improved performance of German companies once the capacity for imitation was increased.

The cross-ownership of banks and major industries can also have the effect of stalling the growth of new technologies. To cite a relevant example, the part-ownership of the major utilities by banks resulted in initial difficulty in accessing project financing for new renewable energy projects. This barrier however, was overcome due to the existence of another aspect of the German innovation system that can be regarded as stemming from the employment of PSG.

The high level of state involvement in the banking and general financing systems of Germany has led to a very strong public banking system. In 1997 52% of the total banked funds in Germany were being held by public banks, as were 30% of all outstanding loans (Weiss 1998, pp.122). Weiss points out that German lending trends have also increasingly been longer term, encouraged through state-provided inducements for longer-term saving. This strong degree of public ownership combines with the German Government's clear view of what areas it wishes to invest in, namely modernisation of basic industry, as well as energy and railways. Weiss also identifies the willingness of the German state to provide finance for this process, albeit while trying to distance itself from having done so through the use of structures designed to give the appearance of a market-driven mechanism. This camouflaging of financing support extended to the European Recovery Programme (ERP) which was extended for use in the form of a Loan Corporation, run similarly to a commercial bank though essentially under Government control. It was thus capable of direction to

precisely those areas which the Government wished to focus on. By continually providing loans at 'soft' rates, stimulation of industry was possible, and the repayment of such allowed the scheme to run on indefinitely. This has continued to the present day, where the ERP is used as one of the largest parts of the financing mechanism for wind turbine projects. This Loan Corporation is the DtA, which has already been described above.

Weiss identifies a thread in German industrial policy, labelled 'state denial', wherein it is suggested that the German state exerts a significant amount of influence but does so from 'behind the scenes'. That is, in such a manner as to claim it has no official policy. Weiss suggests this stems from an unusual mixture of geopolitical pressures including the "search for acceptance in post-war Europe, the economic correctness of the Cold War...[and partly as] a response to domestic fears that intervention would reintroduce authoritarian ways" (Weiss 1998, pp129). Weiss also suggests that the German post-war mindset was such that state guidance was equated with the planned economies of the Eastern bloc, and thus as non-liberal and undesirable in a nation which believed it had to excel, and be seen to excel, in its pursuit of democracy and liberalism. PSG allows the German Government to stand back from openly directing development while actually exerting a significant amount of control, and indeed being an essential part of the system.

Aspects of the system identified by Weiss include the tendency of trade associations and business organisations to rely on Government for their 'organisational subsistence', and the obverse of this, that the government grants these agencies a considerable level of responsibility. Weiss suggests that the arrangement goes beyond the 'politics of industrial order' in providing unofficial approval for the organisation of an industry to the extent where pricing is affected by their actions.

One function of the existence of such a system is the joint co-ordination of the national innovation system, or at least to that extent which the NIS can be said to be co-ordinated. The various German business confederations and associations have a part in running public policy alongside a range of state sponsored agencies and institutions, including the research and training institutions aiming at continuing to provide the skills required for further technological development.

One of the qualities of PSG that Weiss highlights is the setting of goals by the state, which are then expected to be adopted as policy with responsibility for their implementation shared between the state and the private sector, and with initiation of schemes coming from either party. While the state finances the infrastructure needed for continuing innovation, the management of the system is effectively in the hands of the private sector. Weiss suggests that this means the innovation system is 'both slower to respond to changes in the external environment and more restricted in the changes it can make'. Weiss sums up the German situation as strong on incremental change within existing technological fields but weak on the structural changes needed to establish new fields. In this context the initial development of a wind turbine industry in Germany could be expected to be a difficult one, and indeed this seems to be borne out by the historical record. The fact that one has begun to develop is perhaps indicative of the political support that it has managed to attract, and the commensurate funding and market assistance this has brought. It can be noted again that German companies only began to enjoy success when they adopted the 'Danish concept', it is possible to suggest that alterations since then, such as many of those introduced by Enercon, can be regarded as merely incremental improvements to the basic design. This success following imitation would also seem to fit with the profile that Weiss presents. Allen (Allen 1993) argues that banks have the advantage over

stock markets in providing support for established technologies, but are disadvantaged when dealing with the uncertainties inherent in the establishment of companies in new technologies. The preference for bank based funding in the German industrial model thus also ties with greater German success in imitative industries rather than innovative ones.

Weiss identifies a number of further ways in which the PSG acts to limit new technology development; these include the role of the engineer in innovation and the role of the banks in supporting it. With regard to engineering, Weiss notes a tendency for German products to be over-engineered, that is, German companies will produce a high quality product to a high specification and then try to find a market for it, thus the design process is technology driven and tends to be somewhat wasteful of resources. Weiss contrasts this with the market-led approach used in Japan, wherein the level of technology it is necessary to achieve to be able to access a market are ascertained, and this is set as the target to be achieved. Naturally this method results in lower costs.

The other limitation inherent in PSG, according to Weiss and, it might be suggested, in direct contradiction of the conventional view, are the actions of the German banks. It is pointed out that the banks tend to limit themselves to low-risk opportunities, this, Weiss contends, has meant the banks have “failed to provide German industry with a transformative capacity”, and has been another factor which has acted to constrain movement from old to new technologies (Weiss 1998, Chap.5).

Both of these limiting factors may perhaps help to explain why the German turbine manufacturing industry has struggled to compete efficiently internationally. While the programmes created by the German Government have helped to remove some of the barriers to growth in the industry and helped to foster the existence of a

slew of new German companies in the sector, the failure of the industry to compete internationally indicates that there are other barriers to prevent the German turbine industry from maturing and being able to develop effectively internationally. It is entirely possible that these stem from the limiting factors identified by Weiss as being general to German industry.

#### 5.11 Effects of the Federal Nature of Germany

Another German cultural factor relevant to the issues under discussion is the regional level of Government existing below the national level. These give the opportunity for regional Governments to tailor policies specific to particular areas of the country or to focus efforts where they can be most effective. It is also possible though, that individual Länder may elect not to provide support for industry even if other favourable factors exist. Mecklenburg-Vorpommern, for example, has, by German standards, good wind resources due to its coastal position. Despite this it has failed to exploit these to a level comparable with that of either Schleswig-Holstein or Lower Saxony. While Mecklenburg-Vorpommern is one of the former East German Länder and thus there are a number of factors that differentiate its circumstances from its coastal counterparts to the west, enough were similar that at least part of the failure can be ascribed to political indifference on the part of the regional authorities.

Despite a late start however, Mecklenburg-Vorpommern did show an increase in both 1998 and 1999, with around 140 MW of wind turbine capacity installed there in the latter of those two years. Whilst this was still less in absolute terms than the other two coastal German Länder in the same year, the rate of expansion is comparable, and the lesser figure may just represent the late start exhibited by the region (Knight 2000a).



### 5.12 The German Domestic Market

In terms of this research, the most interesting aspect of the German market is the way in which German companies continue to dominate it. Despite their relatively low levels of success outside Germany, German companies consistently capture 60-70% of the German market. There are a number of possible reasons for this. Firstly national pride, and national self-interest may influence the buying habits of customers, but the likelihood of this having a highly significant effect in the consideration of purchases of equipment with a value of millions of Marks is low.

A second possibility is that companies who buy from German producers are likely to be much closer to that manufacturer geographically, thus rendering them closer for after-sales service and maintenance. This argument does not stand up to scrutiny however, given that non-German manufacturers have set up manufacturing facilities in Germany and still enjoy less success than the domestic competitors.

A further possibility is that German companies specifically tailor their products to the needs of German consumers, that is, turbines are designed to exploit the low wind speeds which are more common in Germany than in their chief competitor in the industry, Denmark. It is also possible that German companies are more willing to tailor their products to the specified needs of individual consumers, something which some Danish companies have been increasingly shying away from, preferring to mass produce a generic model in order to keep costs down.

The final possibility is that German policy is constructed so as to give specific advantage to German industry.

The truth is likely to be a mixture of some, or perhaps all, of the above reasons, though to what degree each is present, and has been present through the growth of the industry, is difficult to assess. Obviously a new industry is going to be

more in need of protection than one that has become more established, and protective measures will enable an industry to overcome certain barriers more easily and assist the rapid growth of that industry. Competing with such measures in terms of their relative importance is the apparent significance of being situated close to one's customers. Danish companies have increasingly established operations in Germany itself, but have nevertheless failed to develop anything near the penetration that they hold in practically any other of the world's turbine markets.

Wind energy, renewable energy technologies and environmental technology generally have all been highlighted as important to the future of German employment. In 1994, the German Federal Environment Ministry estimated that by 2000, Germany would have 1.12 million workers in the environmental sector, an increase from 426,000 in 1980 (German Federal Environment Ministry 1994). The German Federal Environment Agency said that this figure had almost been achieved by 1994, and that employment figures were likely to continue to rise in the sector (German Federal Environment Agency 1998). By 2000, the trade journal Windpower Monthly recorded that 20,000 jobs had been created relating to turbine manufacturing. Germany thus has an increasing motivation to see the sector grow, and to see German manufacturers prosper within it (Knight 2000b; WPM 2000b). The German engineering association, VDMA, and a German metal workers trade union have suggested that the EEG should drive this figure to increase, anticipating 50,000 new jobs in manufacturing and 30,000 jobs in operations and maintenance relating to wind power. The VDMA has also predicted that exports should rapidly increase from the current 20% of wind turbines made in Germany to 80% (Knight 2000b).

It is possible that the German national innovation system may have some characteristics which are better suited to encouraging the growth of a wind turbine

industry, at least at the present stage and this is reflected in German success at home. Nevertheless, one would assume that the German subsidiaries of Danish companies would be able to compete effectively and would be under the same conditions within the German market as the German companies themselves. Additionally, one would expect that the Danish companies would bring with them the advantages accrued as a result of both leading the industry technically, and in terms of knowledge and experience of the technology. It is perhaps possible that Danish companies in this case are being run such that their structure is not wholly appropriate to operation in the German marketplace and that business is being lost as a result, and that this may be worthy of deeper investigation.

The most obvious reason for the greater success of German companies however, would instead appear to be that induced for them by the policies of their Government.

### 5.13 The Future of the German Wind Turbine Industry

There are a number of possible directions in which the industry can move, both at home and internationally. After considerable pressure, the original support mechanism has been altered and a number of its initial drawbacks removed. The reform of the EFL to the EEG however has not rid the legislation of its opponents however, and these may be powerful enough to cause a reduction in confidence regarding the realistic availability of long term payments. Other possible changes to the EFL may have a more rapid effect.

The industry does, however appear to have continuing political support, the new administration of the German Government, elected in late 1998, apparently supports the greater use of renewables. Additionally, the pledge to phase out nuclear generation will have a number of implications for the future of wind energy in

Germany, though the implementation of the phase out is likely to occur over an extended period so any effects may become apparent only slowly.

One potential problem that the wind industry may face however is a shift in support away from it, and towards photovoltaics and other new energy technologies. This may take away some of the financial aid which the sector has so far enjoyed, though it is possible that this money is no longer as necessary given the currently buoyant state of the market. The BMFT's 4<sup>th</sup> Programme on Energy Research and Energy Technologies allots DM64 million to photovoltaics annually up to 2001, with wind energy technology R&D receiving only DM40 million a year in the same period (German Federal Research Ministry 1996). Lower Saxony, one of the main focuses for German wind energy expansion and usage, completely withdrew R&D support funding from wind energy projects from 1996, and at the same time increased support to solar energy projects. Schleswig-Holstein also cut the level of financial support to new wind projects each year between 1995 to 1997 and looks set to carry on with this pattern. The reason for this reduction in funding in all likelihood stems from the perception that wind energy technology has developed to a stage where it is mature enough not to need the support that has been apparent previously. Mechanisms such as the EFL, now the EEG, and access to the soft loans of the DtA and other financial organisations means that most projects should be able to survive. Predictably, the German wind industry, its trade associations and journals objected to the Länder level reductions but it is entirely possible that the industry could survive without them, and indeed for them to become stronger as a result. This seems even more likely with the introduction of the EEG. The reduced availability of R&D funding for wind energy, and its concentration in application to PV funding can be regarded as demonstrative of an overall international trend in renewable energy funding throughout the 1990's,

the other significant trend in RE R&D funding in the period being that the overall level for all technologies tended to remain flat, despite political rhetoric in favour of expanding RE usage. (Dooley 1998; Dooley and Runci 2000)

The implementation of the EEG in 2000, with its promise of continued payments for a minimum twenty year period should act to bolster the perception that wind energy is a secure investment, providing its continued future can be assured with regard to the wishes of the European commission.

It remains to be seen as to whether the new law and its new payment regime will be sufficient to stimulate offshore development to any significant level, though it is possible that the law could be adapted to enhance payments if this remains as the only barrier to offshore use. The plans for offshore announced by the German Government in 2001 suggest that the move to offshore is one that the government is aware of and will act to support.

It is not impossible that limits imposed through the EC could act to both reduce the level of subsidy and the length of time over which it is made available, though in light of the ECJ decision that the German tariff system is legal, such restrictions should be some time away. Naturally, the effect of such restrictions would be to reduce the number of economically viable projects, as well as to increase the reduce the perception of turbines as a safe investment, with effectively the same result. What the generous terms of the EEG do indicate is the high level of political commitment that the German Government maintains for the growth of wind energy usage.

#### 5.14 The Reproducibility of German Policy

Germany, as with Denmark, had historical experience of using wind energy technology. This however did not bring the same advantages to Germany that it led to

for Denmark, possibly resulting from the lack of grass roots uptake of the technology. As with Denmark, clearly it is not possible to simulate such historical use. The German experience is not necessarily totally positive however. It can be argued that the German approach to research and development, with a focus on large-scale machines, was engendered, at least in part by the work of Hütter. Where historical use may grant an advantage though, is in creating an atmosphere more conducive to the use of the technology, that is, experience with the technology may make it more likely that a Government will be willing to provide finance for the support of work to advance a technology.

The original German approach to wind turbine development, the building of large-scale turbines, is clearly something that need not be repeated. The industry has moved to the point that to do so would be irrelevant. The technology to produce large turbines, developed through a process of incremental increases, means that such an approach has been superseded and the same basic result can now be achieved through a process of imitation.

What Germany does represent though, is an example of the advance of the technology through the focus on the R&D process. The absence of a notable grass roots movement specifically supporting wind energy, meant that once the initial focus on large-scale, multi-megawatt, equipment had been bypassed, it was possible for the German Government to direct funding into advances which built on Danish work. The existence of a German turbine manufacturing industry thus exemplifies the possibilities which remain even where there is no popular call to use the technology. It seems likely that the actions of grass roots activists became less important after the industry moved beyond the emergent industrial phase and into the growth phase,

which is the point at which German companies began to enter it. This will be discussed in greater depth in chapter eight.

As has been emphasised above, and as with Denmark, one of the most important aspects of German wind energy policy was the creation and continued support of a domestic German market place. Perhaps even more so than in Denmark, it was important for the future of any German turbine manufacturing that such a market could be created and be capable of being directed such that German companies would be favoured. This was initially achieved through the use of a system of grants within the 250MW programme. There are a number of possible barriers to the institution of a similar policy elsewhere. Clearly, the industry has evolved since the period when this subsidy scheme was in place, as has the world outside the industry. Firstly, the introduction of such a subsidy would be notifiable to the WTO under the agreement on Technical Barriers to Trade (TBT), though this does not necessarily mean that any action would be taken to remove it. For any action to occur a complaint would have to be made on behalf of any Government which felt that the measure was unfair to their constituents, and a ruling would eventually be made pertaining to that complaint. For a subsidy policy to be introduced within the EU, the Competition Directorate, DG IV, would have to give approval. If, after approval, grants were allocated other than on an equitable and transparent basis, such action would be worthy of complaint to DG IV, which would be able to take action to remedy the situation through the ECJ.

Further barriers to the introduction of a scheme involving the direction of grants on a national basis stem from its political implications. In some nations, the system of governance will better lend itself to such application than in others, in some the nature of the policy of the governing administration will play a part. The use of a

grants scheme in itself might be acceptable, as with the new subsidy scheme proposed in the UK to support the use of bio-fuels and offshore wind (DTI 2000). Whether it is politically acceptable, or even politically desired, that this be directed specifically to UK companies is a different matter.

Issues relating to political acceptability play an important part in the selection of a support mechanism for renewable energy development. Countries with an early commitment to deregulation and liberalisation of their electricity supply industries may have found, and may continue to find, that it is less acceptable to select a REFIT style of support mechanism, with its implicit lack of competitive structures for the awarding of contracts, and may even be blocked by the application of their existing regulation. As has been mentioned the REFIT style of payment may also be under some threat from the EU's DG IV, through their proposed changes to EU legislation on environmental subsidy, though this now looks less likely in view of the ECJ ruling regarding Germany's use of a REFIT mechanism (Knight 2001).

The same piece of legislation that introduced REFIT to Germany also put in place regulation for negotiated third party access to the grid, allowing wind energy to utilise the grid in the face of opposition from the utilities who owned it. Legislation to guarantee such access should be easily reproducible in other countries. In many it might actually exist where a process of liberalisation has already enabled it.

As with other nations, a potential issue in Germany is the siting of turbines. Wind turbines initial exemption from planning requirements may prove difficult to imitate in many places where strict guidelines already exist to cover any kind of planning requirements. The guidelines which supplanted this near free-for-all gave emphasis to the regions to assess the potential within their own boundaries. This is likely to be a more acceptable policy for imitation across a large range of territories.



It follows the same path as that taken in Denmark, in order to both supplicate those opposing potential damage to visual amenity, and to achieve the secondary aim of acting to accurately assess the level of renewable potential in a region.

The breaking down of regions for the purposes of planning and zoning has already been discussed as regards its reproducibility outside Germany in Chapter Four, with the conclusion that it is generally likely to be possible. The effects of the federal nature of Germany is likely to lend itself less easily to replication in a non-federated country, though it is possible that some of the effects could be copied through legislation at the national level to direct aid to specific areas of a country where this might be desirable.

As Lindley suggests (Lindley 1996), one of the key reasons for the rapid expansion of wind energy in Germany has been the availability of soft loans to those wishing to develop wind projects. The German Government has been able, through the mechanism of its publicly owned banks to direct funds to these as necessary. Whilst it is possible for other countries to direct loans in this manner, not all could necessarily achieve it with the same political equanimity. The ease with which Germany is able to direct funding is a product, as has been detailed above, of its application of public sector governance. The loan system effectively represents the willingness of the government to support those industries it wished to see developed and where there is, as yet, insufficient readiness on the part of private sources to provide full finance. The question as to whether such a policy is easily transferable to another nation is likely to be dependent on the particular approach that country has to government stimulation of markets, the underlying structure that supports its technology policy, and, as Mitchell has described, the national finance system of the country (Mitchell 1994).

### 5.15 Discussion

In many ways the German experience with creating both a wind turbine market and a wind turbine manufacturing industry will be more relevant to other nations considering policy trying to achieve these ends, than the Danish experience. Other new potential entrants will share Germany's experience of having to battle against established market leaders in order to survive. New entrants will also have an established German industry to cope with. Nevertheless Denmark will remain as the chief source of competition.

Clearly, Germany has learned some lessons from Danish policy. Germany adopted an identical mechanism for the financial support of wind energy, as well as seeing its companies adopt the 'Danish concept' design of turbines. It has so far though, refused forthrightly to follow Denmark in switching from a REFIT mechanism to an RPS mechanism as Denmark did in 2000. This would suggest that Germany is still willing to tolerate the high, and rapidly increasing, costs that can be associated with a REFIT mechanism, though it has to be noted that the much larger German population do not pay as much on a per capita basis as the Danish population did under the REFIT mechanism there. The introduction of legislation to equalise payment of the tariff within the EEG means that the payments are more evenly distributed and may thus be more tolerable over a longer period. The steadfast refusal by Germany to give up the REFIT may be interpreted as an interesting indicator of the German wish to continue to be able to protect the wind industry, both from other electricity generating sectors as an environmental benefit, and possibly as a way of continuing to ward off wind turbine manufacturers from outside Germany. The introduction of competition that would come with the initiation of an RPS has the potential to open sales of turbines in Germany to a pressure that German companies

might be less able to tolerate. If the German Government feels that this is the case it's continuing support of the REFIT mechanism would be regarded as essential to protecting their investment thus far.

There can be little doubt that the German market for wind turbines is a protected one, both in the obvious sense that the industry receives subsidies that do not accrue to other energy generators, but also in the sense that funding has been, and continues to be, directed to German interests at the expense of foreign companies. Whilst this may be necessary, at least to some extent, to the continued survival of a German turbine manufacturing sector, it is likely that such protection acts to reduce competitiveness domestically, and the end result is that German companies are less able to compete internationally.

#### Main Points in Chapter Five

- Germany has the largest installed wind turbine capacity, despite beginning development relatively late in comparison with Denmark and the US.
- Germany companies dominate the German domestic market, yet have enjoyed poor penetration into markets outside Germany.
- Expansion of German wind energy has been at considerable expense to German utilities and consumers, requiring considerable spending on their part, and the tying up of considerable amounts of capital from public sources.
- There have been a number of policy mechanisms, primarily of a financial nature, which have potentially or specifically aided German companies domestically, at the expense of non-German companies.
- Both the federal nature of Germany, and the strong ties between German government and banks create conditions which may not necessarily be easily reproducible outside Germany.

## **Chapter Six: The Development of the Spanish Wind Turbine Industry**

Spain is the country which has seen the greatest expansion of wind energy utilisation of recent years. Stemming from this, Spanish wind turbine manufacturers are amongst the most recent entrants to the industry. As recently as 1995, wind energy use could be regarded as negligible in Spain, indeed, the country was not originally going to be included in this research due to its lack of significance. A number of policies have been important in changing this.

### **6.1 The Growth of Wind Energy Usage in Spain**

In 1990, Spain had an installed wind capacity of only 7 MW. By the end of 1999, this had increased to a total of 1530 MW, and 2099 MW was in place before the end of 2000 (WPM 2001). A large number of contracts have also been already agreed which should see the installation of considerably more. The level of expansion is demonstrated in Table 1

Table 6.1 Annual Spanish Installed Wind Turbine Capacity

Year	MW
1995	115
1996	221
1997	512
1998	834
1999	1530

(IEA 1998; WPM 1999b; WPM 1999a; WPM 2000c)

As can be seen the rate of expansion has been variable throughout the period but has remained above 60% annually since 1995. Whilst wind energy has had the highest rate of expansion for any energy source on a worldwide basis, at around 25% annually, this is clearly an outstanding rate of increase, even within the context of the global wind industry.

A number of estimates have been made as to the available potential for wind energy in Spain. The Institute for the Diversification and Conservation of Energy, (Instituto para la diversificación y Ahorro de la Energi - IDAE), a 'mid-autonomous' organisation (IEA 1998) operated through the Ministry of Industry, assessed the level of potential in a range of regions, though in a number of cases these estimates have already been outstripped. IDAE's projections show no figures for projected potential in some regions, where successful developments have now proven that there was potential by realising part of it. In 1997 the Government estimate of wind potential in Spain stood at 2.8GW (IEA 1998). In 1999 IDAE suggested Spain had a total potential of 8.3GW but it is likely that this figure still failed to include some resources. For example, no potential for the region of Castilla la Mancha was described. In the same year the region connected 122MW of wind capacity to the grid and announced a strategic plan which includes the development of over 1000MW. The figures can thus not be regarded as accurately representing Spain's actual potential. The leading international trade journal for wind energy, Windpower Monthly, has suggested that IDAE's estimates for regional and provincial potentials can not be trusted. The magazine cites as examples the region of Castilla Leon, which has assessed its own potential at 2980MW, while IDAE has the figure at 850MW, and Catalonia which has been assessed by IDAE as having a potential of 425MW across the region, whilst local actors there suggest that there is at least 1000MW of potential in one province of the region alone. Thus it is not possible to derive an accurate figure for the potential wind energy capacity of Spain, though even from the targets and already confirmed it is certain that it will be high enough to play a significant part in sustaining the growth of the global turbine industry, if the proper policies are put in place to exploit it.

Spain began the 1990's with a stated target for further installation of wind energy equal to 275MW of capacity to be in place by 2000. This objective was bypassed in 1997. The current target for wind in Spain, as announced by IDAE, is to have 8974MW installed by 2010, as part of efforts to reach the 12% target for renewable energy set by the EU. (McGovern 2000b) In general estimates of likely rates of expansion have fallen short of the actual rates. The IEA, for example, accepted that 'installed capacity could be as high as 750MW by 2000' in a report published in 1998, (IEA 1998) the same year that figure was actually broached.

## 6.2 Spanish Wind Energy Policy

Spanish policy at the national level has been founded on the twin bulwarks of a REFIT style subsidy scheme and of generous capital subsidies. However, regional policies have also played an important in both making wind energy projects economic and in encouraging the growth of new turbine manufacturers.

Spain first gained some experience with wind energy in the 1980's and early 1990's, with developments centred in the Canary Islands and in the Tarifa municipal area of Andalucia. These projects were carried out with the support of the European Community/Union, the Spanish Ministry of Industry and a German electricity utility, RWE Energie, which had expressed an interest in gaining experience which it could then transfer to developing inland wind generators at home. The electricity the turbines generated were sold on to local utilities at the rate paid to any other generator. Only the grants made them economic.

These early Spanish wind projects encountered a number of problems, one notable problem being that encountered at the site in the Tarifa site in Andalucia where a number of avian deaths, including those of a number of protected raptors, were recorded in the area of the turbines. The result was opposition from

environmental activists, as well as legal problems due to the threat to bird species protected under either Spanish or European law. This was effectively a two fold problem, the first aspect being the legal one, the second, possibly more damaging aspect, the potential problem of alienating local opinion against the use of wind turbines.

One important aspect of Spanish law which already favoured renewables was the existence of an obligation on utilities to purchase all electricity from Independent Power Producers at a fixed rate. The intended effect of this being to minimise any problems that Spanish wind turbine owners might face from utilities hostile to the use of renewables.

Spanish wind energy development, and renewable energy development generally, is under the purview of a national renewable energy plan, which forms one aspect of the Energy Savings and Efficiency Plan (PAEE). A wide-ranging national policy on renewables effectively began in 1994 with Royal Decree 2366/1994. This formed the legal basis for the provision of feed-in tariffs for electricity from renewable sources with a capacity under 100MW. The decree instituted a tariff at a rate from 80-90% of the average price paid for electricity, with the specific rate calculated on an annual basis. Until recently this has typically been calculated to equal 88.5%. In 1994, application of this rate amounted to an increase in the tariff available to wind from the 10pta/kWh rate typically paid to IPP's, up to 11.57pta/kWh. The tariff was guaranteed to be paid for a five year period in order to provide increased stability to the market and to thus help encourage investment.

A 1997 adjustment altered the payment scheme, effectively offering developers a choice of two payment schemes. They could opt to receive either a fixed price, in 1997 this being equal to 11.02pta/kWh (0.066euro/kWh), or a variable price

based on the average price paid by consumers for all electricity consumed domestically in Spain, plus an environmental bonus. In 1997 this variable price worked out to 0.034euro/kWh, with an environmental bonus of 0.032euro/kWh, making the two practically the same, though this was not a matter of deliberate policy (WD 1999). This figure was also intended to include a consideration for those avoided costs for the distributor which would otherwise be incurred in the process of purchasing from traditional large scale generators (Cervený and Resch 1998).

Controversially, the payment was reduced, by an average of 5.48%, at the end of 1999 as part of a round of government cuts, (WPM 2000b) though as of late 2000, it was not yet apparent as to what the practical effects of the cut would be.

The adjustment made in 1997, introduced as part of a general electricity law through Royal Decree 54/1997, included the codicil that the new payment regime would apply only to those with a maximum generating capacity of 50MW. Any problem which this might have presented to new large-scale projects appears to have been circumvented through the breaking down of projects into pieces with less than this generating capacity and presenting them as being separate, even where they are practically adjacent.

In addition to the creation of a REFIT style support mechanism the 1994 decree also acted to divide electrical distribution from generation as well as establishing a moratorium on nuclear plant construction.

Alongside the REFIT style mechanism for subsidisation of electrical production from wind generators, there is a second policy plank aimed at supporting the growth in the use of wind energy, and the growth of an industry to exploit it. The IDAE oversees the allocation of capital grants to projects intending to install less than 20MW of wind turbine capacity, with public capital invested with the aim of



attracting private capital to meet the majority of any costs. In 1997, IDAE made ESP10.1Billion (US\$70.6 Million) available to such projects, offering up to 40% of costs. Funding was announced to be preferred for those projects in remote areas with poor levels of grid connectivity.

Research and development for wind energy technology is additionally funded to a small degree at the national level. In 1995, this amounted to approximately US\$1 Million, out of a renewable energy R&D budget of US\$16.3 Million, which in itself is 20.9% of the national energy R&D spend. Perhaps surprisingly, the amount made available for wind research has not increased greatly in the five years since then, despite the large increase in the use of the technology and corresponding increases in the levels of investment and employment. Funding relating to R&D for wind energy is provided within three programmes run by the Spanish Research Centre for Energy, Environment and Technology (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas - CIEMAT). These three comprise a programme aimed at improving large scale turbine performance, funded with around US\$500,000, a programme to improve the use of wind energy in isolated areas, funded with around US\$800,000, and finally, a programme funded with around US\$725,000 is in place to “analyze, characterize and evaluate all technical aspects concerning the availability of power from renewable sources” (Ciemat 2000), though this also covers assessment of potential of renewable energy other than wind. It is notable that this assessment of potential has taken place in conjunction both with European and regional governments, and with many of the major turbine manufacturing and wind farm development companies presently operating in Spain. This is representative of the high degree of integration of efforts that have occurred in Spanish development, with the national government maximising European assistance, encouraging the efforts of

the regional governments and drawing in those from the industry itself in order to facilitate the easier exploitation of opportunity and the growth of that industry. In some ways it is reminiscent of the close ties that have existed between the various actors relevant to the Danish industry since its inception, and which can be regarded as having played a critical part in the success of that industry.

Consideration must also be given to the Spanish potential for offshore wind. Obviously Spain has considerable coastline, though as detailed in the European Wind Atlas (Risø 2000), it does not have as much potential for economic offshore operation due to slower prevailing wind speeds than coastal locations in northern Europe. However, as has been noted, the development of wind is still a very recent and very much ongoing phenomenon and the potential for onshore development is still considerable. Whilst not as much consideration has been given to offshore potential as has been the case in countries such as Denmark, Germany and the UK where there is increasingly land use constraints for onshore wind. At the beginning of 2001, the only plans for offshore development were those announced in October of 2000 for a 200 MW, 100 turbine farm, by the largest of the Spanish developers, EHN, and the Swiss-based Frontierwind. The proposal is still subject to approval, though the mechanism under which this might be granted is unclear, and already significant opposition from environmentalists has arisen. EHN have a record of purchasing turbines from a range of manufacturers, both foreign and domestic, so it is not possible at this stage to suggest who is most likely to provide the turbines for the project. If the reports that 2 MW machines are required are accurate however, this limits the possibilities to Gamesa or to one of the larger Danish or German companies. The proposals for the sites have also experienced some protests from

local communities on the grounds that they may damage fishing, sailing and tourism interests, and have yet to be approved (Merino and Mosquera 2001).

CIEMAT, which has responsibility for Spain's energy research has joined an EU wide effort to assess "all aspects of offshore wind energy, including: offshore technology, electrical integration, economics, environmental impacts and political aspects". Thus it is possible that further investigation of the offshore wind resource will take place at some point in the future, although when this will occur is likely to be dependent on a range of factors including the economics, the necessity of obtaining further generating capacity and any technical difficulties regarding connection.

### 6.3 The Role of Regional and Local Government in Spanish Wind Energy

Whilst national policy has been important in the growth of wind energy and of a new wind energy industry in Spain, perhaps just as significant has been the role of the regions in encouraging its rapid expansion.

As with wind energy potential, the level of action taken for their exploitation has varied strongly from region to region. Whilst some regions have opposed the use of turbines, and some have expressed no interest, a number of regions have shown themselves to be pro-active in their use of the new technology.

To understand the role of the regions it is important to be aware of the governmental structure. Spain has a highly stratified hierarchical system of government, with power for local decisions devolved to relatively low levels. Roughly the hierarchy is national, then regional, regions are split into provinces, and these into a number of municipalities. Many of these levels of government have responsibility for some aspect of the process relating to the removal or establishment of barriers relating to the growth of wind energy.

Action at the regional level has ensured that the policies devised at the national level have come to fruition. The move to exploit wind energy has been led by a number of regions acting individually, though this has expanded to some extent as other regions have seen their success and made various attempts to emulate them.

While Tarifa had developed wind energy projects, problems with avian deaths meant restrictions on further use. The next round of development can be regarded as having been initiated by the regions of Galicia, Navarra, Castilla Leon, and Aragón, and while these can still be regarded as the regions with the most liberal postures on further development, other regions have also initiated significant undertakings.

The sparsely populated north western coastal region of Galicia was the first to commit to serious expansion of wind such that it made up a significant fraction of its electrical supply. In December 1995 the region awarded licences for a total of 2550MW of turbine capacity, adding in the suggestion that more licences would be awarded up to the regions projected ceiling of 5600MW (Luke 1995; Luke 1996). To compete for the award of a licence, developers had to submit a 'strategic wind power plan', detailing a commitment that they would support the growth of manufacturing of turbines in Galicia itself. This could be either through the establishment of factories through the developers associated manufacturing arms, or by purchasing equipment from other manufacturers within the region. A minimum of seventy percent of turbines must thus be manufactured locally. The scale of the capacity available through the licences on offer ensured that a large amount of bids were attracted, and the initial undertaking of 2550MW was oversubscribed. Further licences have since been offered, bringing the number up to 3135MW (McGovern 2000c). The result of this was the installation of 481MW of capacity by early 2000, alongside the establishment of twelve manufacturing facilities and the estimated creation of 650

jobs (WPM 2000a), obviously this has important implications for the continued support of wind energy by the local population and local policy makers.

The licensing process in Galicia was carried out through a company specifically established for the task. This approach should, at least in theory, yield a number of advantages, the company was able to identify potential sites on a more holistic basis, with greater regard for the regional effects as a whole rather than on a piecemeal basis as might otherwise be the case, and thus to more easily avoid any potential environmental problems. Whilst the licences did not include planning permission, which still had to be sought from the relevant authorities at a more local level, the company was able to liaise with these authorities such that this was likely to be granted without objection, or with a minimum of objection.

Clearly, the motivation for the licensing procedure came in part from the desire on behalf on the regional government to secure employment and investment opportunities for the region on the back of the nationally provided subsidy scheme. By enforcing regulations on government approval of all wind projects though, the regional government also wished to prevent the problems relating to the environmental impacts of wind turbines which had already proved to problematic to increased growth in wind energy exploitation in the Tarifa region.

Competing with Galicia until recently, as the most active of the Spanish regions is its neighbour, Navarra. The region had 408 MW online by 2000, with a total target capacity of 700MW. Whilst presently the second most successful region in terms of installed capacity, this target figure though, has begun to make the region look like a relatively small player. Castilla Leon has announced a target of 2980MW, Andalucia 1100 MW, Catalonia 1000 MW and Valencia is thought likely to offer licences for in excess of 1500MW of capacity (McGovern 2000d).

The common thread which ties these regions and their policies together has been the development of strategic development plans. Galicia provided a lead, which was initially followed by Navarra and Aragón, and latterly by Castilla Leon, Castilla la Mancha, Catalonia and Valencia, each of which is in the process or has recently completed strategic plans of their own. Andalucia has begun to assess applications for contracts following environmental impact assessments of its potential wind energy sites. The regions of Asturias and the Basque country have also set themselves what can be regarded as ambitious targets of 300MW and 250 MW respectively, given their comparatively poor wind resources and additional technical problems. The nature and content of the plans has shown variance however, and is likely to continue to do so. Regions with less potential capacity, be it through poorer wind resources, less demand for electricity due to a smaller populace, or environmental considerations, will obviously have less leverage to demand that as much manufacturing be carried out as Galicia is able to with its large-scale commitments to expansion.

Whilst the targets of all of these regions are significant, meeting them is not simply a matter of attracting enough investors and passing applications through the planning process. A number of problems may act to inhibit growth at the rate which the stated regional policies would require.

The most notable barrier to rapid growth as a whole is likely to be local grid infrastructure which, in a number of locations, is insufficient to meet the needs of so much added wind capacity. The problem relates to one of the otherwise attractive aspects of wind energy. The areas which have shown the most interest in wind, and who have amongst the best resources, have tended to be amongst the more remote of the Spanish regions. The rural nature of the areas, and lack of industry, especially medium to high-tech industry, made the development of wind turbine technology, and

of the industry that it has stimulated through the use of strategic development plans, particularly interesting. The relatively sparse populations though have meant that there is a lack of grid infrastructure in place to handle a large rise in extra capacity. The small region of Asturias, for example, whilst setting an installation target of 300 MW for wind capacity, has had to place a ceiling of 120MW of capacity on the licenses it offers. Murcia and Castilla Leon look likely to experience similar problems, though the problem may expand beyond these. Whilst the grid operators are legally obliged to accept wind-generated electricity, they may legally demure in circumstances where the grid is incapable of handling the extra load. At present there is no mechanism or expert body in place to rule as to whether such claims on the part of the local transmission and distribution companies are valid. Clearly, there is the potential for the abuse of such a legal adjunct, though the presence of a number of major Spanish utilities as both manufacturers and developers may mean that any problems would not exist for all developers within Spain, and that the continued development of sites by companies linked to the utilities would act as an indicator that the maximum capacity had not been broached and allow other companies to continue with their developments.

Windpower Monthly records that there has also been an increased level of public opposition to new developments in a number of regions on environmental grounds, though they seem to suggest that this has largely been in those areas which had received more applications and attention from developers than they had expected, and as a result had offered contracts for extra capacity on a more laissez-faire basis than might have been wise. A number had thus been forced to begin public relations exercises emphasising the positive environmental, economic and social benefits of large-scale industrial development of wind energy.

Dealing with the growth of opposition at this level is important not just for the political impacts on regional politicians however, approval for planning permission still devolves to the municipality in which the wind farm will be constructed.

Opposition at this stage could mean approval is not granted and the project as a whole can fail. Some developers have apparently been working closely with regional ministries in order that their bids are looked upon more favourably, creating the potential for cases where the quality of machinery is given less priority than some of the benefits accruing from allowing developments to proceed. The licensing procedure should at least ensure that the potential for siting problems leading from this situation are avoided.

This problem has been dealt with through both educational programmes as mentioned above and through negotiation at the municipal government level as to the provision of economic benefits specifically at the local level. Farmers have been persuaded as to the advantages of giving land over to turbines through annual rental agreements, and local town halls through the fees that have been able to levy on the use of public land.

Perhaps one of the major problems in the near future for wind development in Spain is the sudden sheer popularity of the technology created as the REFIT subsidy mechanism makes an increased number of sites economically viable, with the range of developers this has encouraged into existence, and the feverish activity this has led to. Many of the departments tasked to deal with applications for wind developments at the regional level have been overwhelmed, with the result that they have practically had to shut down to new applications while they deal with those they have already gathered. The large amount of administration may delay some projects, and indeed, whole regional plans for up to a year. Whilst the delay in itself is undesirable, it may



have some positive impacts. An increased range of choices for the licensing authorities enables them to select projects closer to the ideal, and with the provision of greater benefits to the local economy.

#### 6.4 The Potential for Protectionism in Spanish Policy

As with both Denmark and Germany, Spain has enacted policies to encourage both growth in the use of wind energy technology and to encourage the growth in the manufacturing and development industries that go with it. It is possible that some of these policies may provide advantage specifically to Spanish companies at the cost of non-Spanish owned competitors, or may have the potential to be applied to provide such an advantage to Spanish owned enterprises. This section will discuss both the potential for those policies applied in Spain at both the national and regional level to be turned to protectionist ends, and, to the extent that it is possible, whether they may have been used in such a manner.

The central plank of Spanish national policy, the REFIT style subsidy mechanism, as in Denmark and Germany, could theoretically be turned to protectionist ends. As with the schemes in both of these countries though, it would be difficult to do so whilst maintaining any degree of transparency, and would too easily engender complaints, primarily to the European Commission. Spain, with its status as a cohesion nation and thus heavily subsidised to bring it closer to the EU economic norm, may have particular reason to avoid to avoid this.

Spain has been able to take advantage of this cohesion status to gain considerable grants from the EU to help furnish efforts regarding wind energy on the grounds that electrical generation counts as essential infrastructure for ensuring Spain's future economic wellbeing, and thus as a strong trading partner for the other EU nations, as well as on environmental grounds. Spain has thus been able to secure

funding from diverse European sources including both social and economic programmes like the European Regional Development Programme, plus R&D programmes like Thermie.

The system for awarding grants for smaller wind developments might have more potential for direction to those projects which elect to purchase from Spanish manufacturers. The vague criteria for the allotment of these funds make this possibility even easier to apply if desired, though it is difficult to prove that it direction of the purchase of turbines from specific manufacturers actually occurs.

The real potential for protectionism though, lies with the actions of those who exert control over the provision of licences at the regional level of government. This level of authority, with effective powers over which companies are included or excluded from operating in their region, means that not only are social goods such as employment secured for the local population, but the potential for returns on investment may also be skewed towards manufacturers who, for example, are more likely to maintain a manufacturing base in a particular region to serve the needs of other regions, and perhaps eventually, the export market. With the awarding of licences on grounds which are not simply with regard to the highest bid in currency terms, the level of transparency of the process can be reduced.

This form of protection could be regarded as also possible at the municipal level, at which planning permission must be approved. Whilst it is feasible that government at this level could act to favour domestic industry to the cost of their competitors, there is no evidence to suggest that this is the case. Indeed there is considerable anecdotal evidence that authorities at this level are more responsive to offers which maximise financial benefits to their communities directly rather than in capturing employment opportunities, though this form of financial support for the

community can still be regarded as a social good. In any case, their political power, and the volume of capacity they have control over is not sufficient to provide enough leverage to force the construction of manufacturing facilities. Thus protectionism does not generally provide much of a motivation for the application of policy at the municipal level.

In terms of international reaction to Spanish policy, the use of a REFIT style subsidy scheme has attracted considerably less attention in Spain than in Germany, though a much lower rate per kWh in Spain means that the overall costs burden is much lower. Though it should be borne in mind that the REFIT mechanism has been in place for less time in Spain than in Germany.

The keen involvement of the major utilities in the development of wind farms in Spain can be juxtaposed with the animosity which existed between developers and utilities in Germany, where the REFIT has attracted the most protest, and this may have played a part in bringing it to the attention of the EU authorities. The ruling of the European Court of Justice (ECJ) in the case of the German EFL mechanism as detailed in chapter five, that the use of a REFIT style mechanism is legitimate form of government support means that the EU is unlikely to try to take action against the use of such a mechanism in Spain.

### 6.5 The Growth of a Spanish Wind Turbine Industry

Spain has had a small manufacturing presence for longer than might be expected. Ecotècnia has been operating since 1981, and Desarrollos since 1993, both serving the domestic market at the smaller scale end of industrial turbine production. Gamesa has been in existence since 1976, but it is only more recently that Vestas has become involved. It was only with the rapid expansion of the Spanish market from

around 1995 that these companies began to be significant in terms of the volume of the world market that they were now serving (Directoria 2000).

By the end of 1998 Spain was home to four of the eleven largest turbine manufacturing companies operating in the world, albeit some of them with degrees of foreign ownership.

Table 6.2 World's Largest Wind Turbine Manufacturing Company's 1998

Rank	Manufacturer	Country	MW sold 1998	% 1998	MW sold total	% Total
1	NEG Micon A/S	DK	608	23.4	2.273	22.4
2	ENRON Wind Corp.	USA	424	16,3	792	7,8
3	Vestas Wind Systems A/S	DK	385	14,8	1.878	18,5
4	Enercon	D	334	12.8	1.065	10.5
5	Gamesa	E	171	6.6	360	3.5
6	BONUS Energy A/S	DK	149	5.7	859	8.5
7	Nordex	DK	131	5.0	332	3.3
8	Made	E	105	4.0	232	2.3
9	Ecotècnia	E	47	1.8	77	0.8
10	Mitsubishi	JPN	38	1.5	279	2.7
11	Desarrollos	E	27	1.0	121	1.2
Other Companies			113	4.4	2.170	21.4
Total			2,530	97.0	10,436	103.0

Note: Ranking by megawatt sold in 1998. Total worldwide production in 1998 was about 2,600 MW, the 11 largest producers thus account for 95 per cent of worldwide production of Wind Turbines. (DK=Denmark, D=Germany, E=Spain)

(FDV 1999)

The companies have disparate origins. The largest, Gamesa, is owned largely by a company which is in itself owned in equal parts by a large and diverse Spanish power and banking conglomerate, Iberdrola, and by the major Danish turbine manufacturer, Vestas. Gamesa has thus benefited from both familiarity with local business conditions and of having access to the developed technology. It thus has access to both proven technology and to a developed business network in which to operate, with the involvement of previously successful Spanish interests acting to increase confidence in the company. The company has been able to achieve a position of dominance in its home market through the capture of a number of major

contracts. It won the largest share of any of the contracts awarded in the pioneering region of Galicia, with 600 MW of licences being originally awarded. The company asserts that it claimed a 57% share of the Spanish market in 1999, making it the third largest of the world's manufacturers in that year (Gamesa 2000), while the European Wind Energy Association's magazine, *Wind Directions*, suggested that they had become the second biggest in the world by the end of 2000 (Merino and Mosquera 2001). The level of success that the company has enjoyed has enabled it to establish manufacturing facilities with the claimed capability of producing 1550 turbines annually, equivalent to 1050 MW of turbine capacity. The scale of this commitment is part of the companies obligations within the agreements made in order to secure licences. Thus it reflects the policy adopted by the regions to drive the growth of the industry.

MADE, established in 1986, are a wholly owned subsidiary of the Spanish utility, Endesa, which, quite unusually in the European context, decided it wished to become involved in turbine manufacture as well as in wind project development as a company in its own right, rather than just accept wind generated electricity from IPP's. Through its Co-generation and Renewables arm, Endesa also has interests in both wind project development and in a number of industries which support turbine manufacture. Endesa claim that their combined interests have a total market share of 31% (Endesa 2001). MADE account for a significant fraction of this. MADE claim a total of 96.7MW of turbine installation during 1999, for an overall total installed of 456 MW (McGovern 2000a).

A merger of Iberdrola and Endesa in 2001 was called off after the government set down conditions for the merger to ensure continued competition which the two

companies felt were unacceptable (Economist 2001), and thus Gamesa and MADE remain independent for the present.

Ecotècnia, as has been mentioned, is the oldest of the Spanish companies, and forms a part of the Mondragon Corporacion Cooperativa. Windpower Monthly described it in 1997 as a “small but dynamic organisation made up of prudent economists, top technicians and committed environmentalists” (Luke 1997). It remains relatively small in comparison with Gamesa and MADE, lacking access to the level of financing available to either of these, or to either the internationally proven technology and in-depth experience of Vestas, or the opportunities offered by being a large scale utility such as Endesa. Ecotècnia claim to have installed 70.61MW of turbine capacity in 1999, more than doubling the total it had previously sold and indicating something of a move to maturity for the company.

Desarrollos are a subsidiary of another Spanish conglomerate, Abengoa, whilst once the largest of the Spanish based manufacturers, and enjoying some success in 1998, they appear to have made no installations in 1999. Their position as the fourth largest producer was usurped for that year by Bazán-Bonus, the Spanish manufacturers of Danish Bonus turbines.

It is also worth noting that, whilst not having a Spanish based subsidiary, the Danish NEG-Micon have sold a number of turbines in Spain, adding 27.45 MW of installed capacity in 1999, a figure which was actually a substantial drop from the 74.7 MW it achieved in 1998 (McGovern 2000a). It should be noted that sales of that magnitude made NEG-Micon a significant supplier in the Spanish market.

The success of MADE and Ecotècnia indicate that it is possible for Spanish operators to survive against the ingress of more experienced foreign competitors,

though the lack of activity from Desarrollos may have to serve as a warning that even the protection of the domestic market may not make the Spanish companies safe.

Spanish companies have been able to thrive in the Spanish market where they may be able to accrue some advantage from the home market and from potentially protectionist policies which may offer them extra assistance. The key to their long term survival, further expansion, and to Spain profiting from its investment in the creation of a home industry though, is to exploit the expanding international market for wind turbines. Exploiting the international market makes it much more likely that manufacturing facilities will be maintained in Spain to serve the rest of the world, rather than close as the Spanish market becomes played out. Successful Spanish companies internationally also means profits from outside Spain entering the economy to the benefit of both the balance of trade and, potentially, to internal re-investment.

The latter part of the year 2000 saw deals that may signal the beginning of some degree of Spanish overseas penetration, or at least be perceived as indicating the possibilities of the Spanish companies operating internationally. Gamesa signed a deal with its parent company, Vestas, to provide blades for use in the US, which while a positive sign can obviously be regarded as something of an internal company arrangement and not really open to the level of competition that might be expected on the open market. Endesa announced at the end of December 2000 (Endesa 2000) that it had won contracts to develop 3,000 MW of wind turbine capacity in Argentina, no comment was made as to the likely sources for the equipment to be used.

#### 6.6 The Reproducibility of Spanish Wind Energy Policy

The REFIT-style policy used as the chief subsidising mechanism for wind in Spain has already been discussed with regard to its reproducibility in the chapters

concerning Denmark and Germany. To recap somewhat, such a policy is likely to be technically reproducible with any barriers likely to be politically or culturally derived, and relating to liberalised markets for energy. That is to say, any barriers are likely to derive from opposition to the adoption of a mechanism which is at odds with the free operation of the market, and which lacks any instrument to reduce the prices through competition.

The second facet of Spanish policy at the national level, the allocation of capital grants, is a simple one to mimic. Whilst some political barriers will generally exist to any new provision of public funding, with regard to wind technology the application of direct capital subsidies can be justified, both in terms of environmental commitment and industrial development, thus making wind energy more acceptable than many other candidates for funding. Technically, provision is simple and should fit easily within any industrial or governance system.

The very hierarchical nature of the Spanish system of governance has been central in many ways to the development of wind energy and to the stimulation of a turbine manufacturing industry. However, this very nature may mean that some of the policies adopted in Spain may not, necessarily, be transferable to countries which lack similar structures. Some policies may be capable of adoption though, and some may be easier to adopt than others.

The level of activity that has occurred at the regional level can be strongly linked to the level of legislative autonomy that the regions enjoy. Reproducing the policies that have been successful at the regional level though may not require a similar governmental system. It is possible that this has been successful in Spain as the regions have, at least in some cases, offered just the right size of area to present opportunities for industrial development economically, clearly there must be a



minimum amount of good wind energy sites to use as leverage to drive an industry and justify the setting up of industrial capacity, whilst not being too large that the process becomes unwieldy. It might therefore be possible for other countries to apply similar regional breakdowns within which to pursue effectively separate policy goals.

The creation of strategic plans for the exploitation of wind energy, and for taking the maximum advantage of the industrial opportunities this presents, seems a straightforward concept. In some ways it can be regarded as having parallels with the Danish obligation, placed on the districts there to assess the local potential for wind energy and other renewable energy installations, or with a similar assessment now taking place in the regions in the UK, though carried a number of degrees further.

Nations lacking such a structure may find it more difficult to mimic the arrangements that some of the regions have come to with regard to licensing. Even with the provision of such a licensing structure, further changes might have to be made to alter the particular planning regimes which apply to wind turbine construction, obviously the degree of difficulty this entails will be dependent on the particular mechanisms for the granting of planning consent presently in place, as well as the attitudes to the planning process in individual countries and to the use of the technology in general. Policy in a number of countries has been to encourage greater take-up of wind technology through emphasising the financial benefits to rural landowners, as has been described with regard to both Germany and Denmark. Neither of these though have gone as far as to have municipal authorities brokering for financial deals as appears to have been the case in Spain. With regard to applying this aspect of policy in the UK however, applying benefits to the community is regarded as an acceptable part of the planning process, though the level of transparency would in all likelihood have to remain high in order to avoid judicial

challenges. Also, whilst in the Spanish application of licensing of windy sites, applications for planning permission must, in theory, be applied for from the independent municipality, in practice however, this has been treated as something of a formality, with actual permission being granted following a deal with the planning body. It is unlikely that such a system, however informally it is applied, could be successfully be introduced in the UK, though some changes to the UK guidelines on comparison of local and global impacts may mean, in real terms, a relaxation of the planning constraints on wind developments there, with the result that a licensing system might be more valuable than is presently the case.

### 6.7 Discussion

Spain, and the Spanish development of wind energy, and of a wind turbine manufacturing industry, is important in the context of this research for a number of reasons.

Firstly, the example of Spain presents, in simple terms, an argument that it is still possible to develop a wind turbine industry, even given the level of mature industry that exists overseas. It helps to demonstrate some of the basic requirements for this is to occur.

Secondly, and more importantly, for reasons relating to the theory for entrepreneurial opportunity presented by Low and Abrahamson as described in Chapter Three, and which will be discussed in greater depth in chapter Eight, the industry that has developed displays some signs of what might be a change in the industrial phase of the industry, an advance that may have important implications for the industry as a whole, and for any new entrants to it.

As with Denmark and Germany, the importance of developing a home industry is one of the key elements of policy, with particular emphasis being placed

on the potential for job creation in the Spanish regions, notably in remote and rural regions with high unemployment. Obligations on manufacturers to establish a domestic manufacturing capacity is emphasised in Spanish policy, particularly at the regional level, and the result has been the establishment of both Spanish owned companies, and subsidiaries of non-Spanish companies, as significant producers of turbine capacity.

What is perhaps also notable is the low level of public R&D spending that the sector has attracted, even while expanding at a phenomenal rate. This may be an indicator that the Spanish government regards the industry as having moved to a stage where R&D is no longer required, and the success of the Spanish companies may indicate that this is actually the case.

A further notable phenomenon within the Spanish wind industry is the willingness of turbine manufacturers to also act as major developers. Whilst many of the world's established turbine manufacturers are involved in the development of projects, Spanish companies have moved into the area rapidly and on a more considerable scale. This increased level of vertical integration of companies acts to reduce the overheads inherent to the value chain, and thus increases the operating efficiency and competitiveness of the companies involved. Such increasing vertical integration can be regarded as typical of a business operating in an increasingly maturing industrial sector.

Maximising savings in the value chain may be an important part of the survival of Spanish companies, even in their domestic market place, though it may also have important implications for their possible international expansion. The Spanish companies clearly have less experience than most of the major wind turbine manufacturers and in order to remain competitive must seize any chances to increase

their efficiency. For this reason it may be significant that each of the successful Spanish companies is backed by a larger parent company than is typically the case in the wind turbine industry. It is possible that smaller companies may not have been able to access the level of capital to be able to both establish as manufacturers and developers on the scale that has occurred with the presently successful Spanish operators. They would thus not have been able to claim the benefits of reduced margins this offers and to achieve the same level of competitiveness.

Clearly, if the success of Spanish manufacturers has been dependent on seizing a greater portion of the value chain, then Spanish companies wishing to be successful internationally may have to continue to function as both manufacturers and developers when operating outside Spain in order to maintain their advantage, though continued operations purely in the Spanish market mean that they will increasingly build their experience and knowledge capital and thus claim some reduced costs.

The possibility that Spanish companies needed to be above a certain size for survival is an interesting one in terms of what it may indicate for the industry as a whole. If larger companies, and thus access to a larger supply of capital, have become essential for survival, it may have implications with regard to assessing the industrial phase of the industry. In turn, this would be likely to have further implications for those companies already operating in the industry, as well as for new entrants. A topic which will be discussed in considerably more detail in chapter eight.

In many ways, it can be argued that Spanish policy may actually be superior to German policy, in that it may be more accepting that it will not be possible for Spanish companies to claim all of the new manufacturing opportunities offered, but attempts to ensure that a considerable fraction of manufacturing takes place *in situ*. It thus acts to ensure that the economic and social benefits of stimulating the industry

are still accrued to a large degree by the local community, even where non-domestic companies cater to significant sections of the market, and does so without the significant commitments of public funding that have been necessary in Germany.

#### Main Points of Chapter Six

- Spain now has the second largest installed capacity of wind turbine generators, despite beginning development only around 1995.
- The Spanish regions have played an extremely important part in securing the establishment of manufacturing facilities within Spain, through the linking of local benefits of development with the award of contracts.
- The policies successfully put in place in Spain may be transferable to other nations in encouraging domestic manufacturing of wind turbines, and other renewable energy technologies.
- Spain provides a simple indicator that it is still possible for new companies to enjoy success in the wind turbine manufacturing industry.

## **Chapter Seven: Wind Energy in the United Kingdom**

### **7.1 Introduction**

The United Kingdom provides an interesting example of a country which has been active in encouraging the increased use of renewable energy, including wind energy, without as yet developing a significant level of industry itself. The UK had had in place one of the most novel schemes for supporting renewable energy projects and this has led to considerable interest and a range of assessments of its level of success, its appropriateness with regard to what it set out to achieve and what it fails to address. The UK has also had in place a policy aim which commits it to trying to stimulate internationally competitive industries to exploit renewable energy.

The European Renewable Energy Study (TERES) describes the UK as the European Union country that obtains the lowest fraction of its energy needs from renewable energy sources renewables, with these sources playing an almost negligible role in the UK's energy balance, despite wealth in such resources (ACORD 1994). Despite action to increase the level since TERES was published, the UK remains near the bottom of the list, having overtaken only Belgium, which has far more meagre sources for renewable energy. The reasons for this are numerous and will also be discussed in depth in this chapter.

### **7.2 A Brief History of Wind Energy Technology in the UK**

The UK has amongst the 'best' wind energy resources in Europe; Gipe quotes an estimate by Andrew Garrad that the UK has in the region of 28 times the resources of Denmark (Gipe 1995, pp42).

Development of wind energy technology was bundled in with R&D for all renewable energy sources in the UK, where again it was a response to the oil crises of the 1970's. Wind was initially classified as being one of the technologies least likely

to develop to an economically viable stage and was thus provided with only a low level of funding. A 1982 review by the Advisory Council on Research and Development for fuel and power (ACORD), along with a report from the Energy Technology Support Unit (ETSU), led to a reversal in wind's fortunes however, at least in comparison to the other renewable energy technologies. R&D allocation was as follows for subsequent years;

Table 7.1 UK Dept. of Energy R&D Expenditures (£ Mio.)

	1983-84	1984-85	1985-86	1986-87	1987-88
Wind	2.5	4.8	5.4	3.7	4.0
Solar	0.9	0.5	0.7	0.8	1.1
Tidal	0.0	0.3	0.1	0.1	1.4

(Elliott 1989)

The ETSU report however, also emphasised their estimate that renewables would not be able to provide more than a maximum of 5.8% of Britain's electricity needs by 2025. This estimate that was reinforced with further reports from both ACORD and ETSU in 1986. The funding allocated to wind was used to assist the finance of a number of projects. These included work on a 3MW machine in the Orkneys, developed in conjunction with the Wind Energy Group (WEG), and a 130kW turbine in Wales. Elliott (Elliott 1989) suggests that the renewable energy community regarded this usage of funds as evidence that the Government recognised the need for renewables to have some form of support to assist their movement towards viability in the private sector, but that the Department of Energy actually regarded them as demonstration projects intended as the stimulus for the full-scale private sector deployment of turbines. In a response to a Parliamentary question in 1988, the then energy Minister, Michael Spicer, made the Government's position

clear with a statement to the effect that no grants were available, nor were any to be made available for members of the public to utilise renewable energy.

The June of 1988 also saw the publication of Energy Paper 55, which provided an outline for further RD&D efforts, including details of plans for a collaborative project with the Central Electricity Generating Board (UK Department of Energy 1988, pp11). The paper also contained an invitation to industry to increase its level of involvement with the aim of moving towards the economic exploitation of renewable energy “for the benefit of all in the United Kingdom”. It also acknowledged a drop in the previous estimation regarding the costs of wind generated electricity, suggesting that large-scale onshore wind farms should be able to generate at 2.7-3.4p/kWh by the year 2000. Despite this, the paper would only classify onshore wind as “promising but uncertain”, the second of three categories relating to the likelihood of technologies becoming useful. Offshore wind was classified as a long shot, that is, in the category of technologies regarded as least likely to become economically useful.

Finally the paper outlined further tasks for the continuing R&D programme, and targets for it to achieve. These included a full assessment of the potential in the UK, and the stated aim that development should “provide a basis for the future commercial exploitation of wind energy by developing and demonstrating the technology in close collaboration with the manufacturers and the electricity supply industries”(UK Department of Energy 1988, pp19).

The paper detailed the level of Government spending which was to accompany the new research. This was to comprise of a total spend of £36million by the Department of Energy expended on what it labelled Stage 2 of development of wind energy technology, which it expected to be balanced with a spend of £38million by industry. This was to be followed in stage 3 by a further Departmental spend of



£40million, this time with an expected input of £120million from industry. The basic concept was thus based on an expectation that the input of funding from industry would increase to replace the gradually withdrawn Government financing. It was projected that all funding would come from industry by 2000 (UK Department of Energy 1988; Elliott 1989).

The year after Energy Paper 55 was published, the UK electricity supply industry was privatised. Privatisation saw the introduction of the Non-Fossil Fuel Obligation (NFFO). The NFFO mechanism was primarily aimed at supporting the nuclear industry, which was regarded as likely to be an undesirable purchase for investors. Renewable energy was attached to the NFFO mechanism through the addition of a separate section of the Electricity Privatisation Act (Halsbury 1995; Mitchell 2000). The NFFO remained the central mechanism for the funding of wind energy projects, and for other renewables projects, in England and Wales until 2000, when the end of the pool price system meant its breakdown, though contracts awarded through it continue to be honoured under transitional arrangements made as part of the NFFO's replacement with a Renewables Obligation (RO), and the last contracts awarded within the NFFO were awarded in 1998.

Energy Paper 55 also laid down the UK's motivations for efforts in providing support to renewable energy. The stated intention of policy was to;

- Stimulate the full economic exploitation of alternative energy resources in the UK;
- Establish and develop options for the future;
- Encourage UK industry to develop capabilities for the domestic and export markets.

This aim of developing an internationally competitive industry for the UK is one that appears repeatedly in documents concerning the policy of the UK towards renewable energy technology. It is repeated in Energy Papers 60 and 62, and in statements from relevant Government ministers regarding different rounds of the NFFO. It has also been repeated in the latest statements on UK policy up to 2001.

Energy Paper 60, published in 1992, and comprising a report from the Renewable Energy Advisory Group to the President of the Department of Trade and Industry, also emphasised the environmental benefits of renewable energy. More importantly in terms of this research, it noted the efforts being made in other countries to encourage and support RD&D in renewable energy technology and urged that the UK follow this lead. It recommends however, that this support be largely restricted to those technologies which appeared likely, at the time of publication, to become economic within a 'medium term time scale'. The paper also makes a number of recommendations regarding possible policies to pursue to attempt to remove barriers to the growth of renewables in the UK (DTI 1992).

Energy Paper 62 (DTI 1994), published in early 1994, restated the basis for British efforts in encouraging renewable energy to include consideration of the environment. It went on to outline the Government's estimation of the prospects for the use of renewable energy in the UK and what was to be the official government line for UK policy regarding the technology. The strategy outlined five objectives as the basis for UK policy, these were;

- stimulating an initial market for electricity producing technologies close to commercial competitiveness via the NFFO;
- assessing and developing technology options;
- ensuring that the market is fully informed;

- removing inappropriate market barriers;
- encouraging internationally competitive industries to develop.

(DTI 1994)

The paper also reassessed the forecast for RD&D support of the technology, referring to the existence of an extended programme providing funding up until 2005 subject to a review within five years. A budget of £19.78million was provided in 1994/95, with the Paper presenting the opinion that this amount would diminish over time up to 2005, as ‘technologies move towards the market’. Energy Paper 62 continued to represent the Government belief that public funding would be matched by funds from the private sector, though the estimation of the amount forthcoming from that source diminished considerably from the figures envisaged in Energy Paper 55. Wind energy technology is singled out as having the potential to provide a significant amount of electricity within the UK, as well as offering business opportunities to UK industry, both domestically and internationally, and outlined a programme aimed, at least in part, at encouraging competitiveness in these markets. The paper justifies the programme with the assertion that Government support had already led to the creation of an infant industry, which, it also suggested, would be in a position to effect the “efficient and timely exploitation of market opportunities when they emerge”. A report produced by the National Audit Office (NAO) (National Audit Office 1994), also in 1994, suggested that the UK R&D programme had always been influenced by the market and the main participants. Thus, before 1989 the programme was dominated by the requirements of the CEGB, and afterwards by those involved in the generating sector as a whole. Though not specifically referred to, tying the research programme to the industry in this way could have provided a positive link between the RET industry and the utilities and government if handled

properly, though the post-privatisation period was one when renewables were generally given a low priority by market actors. On impact of the focus on market actors in the R&D process was to emphasise research on large-scale projects better able to fit with the centralised thinking of the time. This can be viewed as another reflection of the large-scale focus which led wind technology research to fail in so many countries. It also demonstrates a further failure on the part of government in relying on large companies to be able to capitalise on new technology, and to lower opportunities for SME's. This lack of SME involvement can be compared with the high degree of involvement they enjoyed in Denmark, where the industry was most successful. The NAO suggested that closer collaboration with industry would be likely to lead to greater benefits in addressing the needs of industry with regard to generating export markets.

Perhaps the most interesting aspect of the NAO report was the admission by the DTI that no emphasis had been placed on addressing the potential for export opportunities in supporting the RD&D programme (National Audit Office 1994, para.12), in the belief that export potential would be addressed by other aspects of renewable energy policy. The Department responded that it would be considering the relevance of exports in its review of the period.

A review of UK renewable energy policy, after being promised for a number of years in the late 1990's, and after repeated delays, finally resulted in the publication of a new policy document in February 2000. Unsurprisingly, this review, 'New and Renewable Energy: prospects for the 21st Century - Conclusions in Response to the Public Consultation', maintained that the establishment of a competitive UK industry should be a key element of UK renewable energy policy.

This document was followed in October 2000 by the Renewables Obligation Preliminary Consultation, which confirmed the RO as the mechanism of choice and discussed some of the implications for the renewable energy generators, and offered the opportunity for input on the operating procedures for the mechanism.

At the time of writing, the statutory consultation concerning the obligation was open for submission. This set down the proposed operating conditions for final legislation, though obviously these are not fixed until the law reaches the statute books.

Clearly, the stated UK policy on renewable energy technologies, has been that they are a worthwhile investment with regard to the possible future capture of markets. UK industry however, has not been capturing significant portion of markets for these technologies. This failure encompasses what is now the largest renewable energy market, the rapidly growing wind turbine market. There a number of possible reasons for this failure. These include the nature of the support provided for the industry, the level of success in removing the barriers to its growth, and the environment in which the industry would have to try to survive. Each of these will be expanded upon in this chapter.

### 7.3 The UK Electricity Supply Industry

The recent history of the UK's electricity supply industry (ESI) is both controversial, and of significant interest in terms of chronicling the development of renewables within a unique framework of conditions. From the mid-1960's to the mid 1980's the UK ESI was a fairly typical state-owned system, run by the Central Electricity Generating Board who were responsible for the generation and transmission of electricity, and perhaps was only significant for its poor management

strategies. Responsibility for distribution lay with the twelve regional electricity boards. Despite improving its performance, the CEGB was split up during the 1980's as a forerunner to the privatisation of the electricity supply industry that took place in 1989. The original plan for the splitting of the generation side of the UK ESI was to have two companies, National Power and Powergen respectively taking a 70:30 share of already existing facilities, with National Power taking over the operation of the UK's nuclear capacity. It rapidly became apparent that the potential investors in the privatisation did not regard the purchase of the nuclear sector as desirable, and fearing for the failure of the sell-off, the nuclear generating facilities were withdrawn from the sale and remained in public hands. A mechanism was thus needed to subsidise the electricity produced from the nuclear sources, this mechanism was to be the Non-Fossil Fuel Obligation (NFFO). The later inclusion of renewables in the scheme linked their funding to that of nuclear energy, regardless of what implications that might have for the renewable energy technology.

In 1989 the UK Government announced a target for the installation renewable energy of 600MW of installed 'declared net capacity', to be in place by 2000. In 1990 this figure was raised to 1000MW by the Government's White Paper on the Environment, "This Common Inheritance" (DOE-UK 1990). It was further raised to 1500MW, to be in place by 2000, in the Coal Review White Paper. This figure being confirmed in the Third Annual Report following the Environment White Paper in 1993 (DOE-UK 1993). The government has failed to meet this target, largely due to an overestimation of the rate of success for the contracts awarded within the NFFO mechanism. The targets were changed in 2001 with the Renewables Obligation Statutory Consultation Document fixing a 10% target by 2010 (DTI 2001a), and a separate press release from Brian Wilson, the then Energy Minister laying down

targets of 3% of electricity sales from renewable sources in the period to March 2003, rising to 10.4% of sales for the year ending March 2011 (DTI 2001b).

#### 7.4 The Non-Fossil Fuel Obligation

The basis of the NFFO, as it applied to renewables, was unusual at the time of its introduction, in that part of its central focus was the application of competition to the technologies in order to drive down prices. This can be seen to be at odds with the REFIT models favoured in Germany, Denmark, Spain and a host of other countries, wherein the primary focus is on encouraging increased capacity, and increased output from renewables. This competitive nature would have a major impact on the way in which renewables developed in the UK.

As has been mentioned, the NFFO mechanism was introduced as part of the privatisation of electricity that took place in the UK.

The NFFO required public electricity suppliers to make orders for sufficient non-fossil fuel generated electricity, as defined by the relevant Secretary or Minister of State, with the responsibility generally lying with a Minister at the Department of Trade and Industry. From 1989 until the bulk of the UK nuclear sector passed into private hands in 1996, this included all the electricity generated by nuclear power stations in the UK. It also includes a small amount of renewable capacity as specified in orders made by the relevant Minister. The subsidy, as specified in the 1989 Act was provided through the Fossil Fuel Levy (FFL). This levy was placed on all sales of electricity generated from fossil fuel sources, with costs being passed on to all electrical consumers. The FFL and disbursement of all levied funds was the responsibility of the Non-Fossil Purchasing Agency (NFPA). The FFL amounted to an addition of around 10% to electricity bills up to 1996 though the vast majority of this money went to subsidise nuclear power. Renewables received 0.5% of the total

levied in 1990-91, increasing to 8% in 1994-95, amounting to £6M out of £1,175M in 1990-91, and rising to £96M out of £1,204M in 1994-95. (Mitchell 1995)

Though comparatively tiny, even this small amount had the potential capability to incentivise some growth in a sector which, at the time, was practically non-existent. However, the bundling of renewables with nuclear led to a further constraint being applied to the support available through the NFFO.

Originally, the UK Government had asked the European Commission (EC) for permission for the FFL to be charged for an indefinite period of time, with an expectation that this would be a minimum of fifteen years. The Commission ruled, however, that the high combined costs of supporting nuclear and renewable energy, would be an unfair burden on UK electricity consumers. The EC imposed a restriction limiting the charging of the FFL to a maximum of eight years. The emplacement of this limit had a number of impacts on the way in which the early rounds of the NFFO affected the growth of renewable energy use in the UK.

The ruling also meant that the subsidy could only be available during the specified eight year period, ending in 1998. That is, it would not be provided for eight full years from the time a generator came online. The more time projects took to become operational, the less time remained for them to claim the subsidy. The somewhat predictable result was that developers tried to rush projects through as rapidly as possible. This was essentially a reflection of the aim of the mechanism as supportive of the nuclear industry, where it was a subsidy for existing capacity, rather than for the stimulation of new capacity which was the condition which would have suited renewable energy.

The short period of subsidy availability, in acting to drive developers to try to bring projects to readiness as rapidly as possible, resulted in a rate of attempted



expansion such that it provoked a backlash from the public in protest against what was seen by some as a too rapid transformation in large areas of countryside. In defence of the NFFO though, it should be noted that the rapidity of the expansion of wind in this period was considerably lower than has proved to be the case in a number of European countries where other mechanisms have been employed.

The announcement regarding the time limit came alongside the imposition of a 6p/kWh cap on payments for renewable energy by the Department of Trade and Industry (DTI). This, however, was unfeasibly low to support a number of potential projects, given the limited time that the subsidy was to be available for, and was raised to 9p/kWh for specified technology bands, including wind energy.

The first round of the NFFO, NFFO-1, also highlighted a number of other problems with the operation of the mechanism. The negligible history of renewables in the UK meant that accurate justification of prices was problematic. There was difficulty in pricing electricity from renewable sources and thus proper competition was effectively ruled out.

Furthermore, the Regional Electricity Companies (REC's) were still in the process of privatisation during the first order, and thus tended to regard it as a low priority. Uncertainty over the final shape of the privatised industry also meant that applicants were in a position whereby they might be sending the financial details of their operations to potential competitors, an action about which they understandably had misgivings. The overall effect of these problems, and of the limits placed on subsidy availability, was that only 100 applications were finally made for contracts, of which 75 were awarded. Sixty three of which were generating in 1999 (Mitchell 2000).

The second round of orders for renewable energy projects within the NFFO took place in 1991, and introduced competition between projects in the same technology bands. With the subsidy still only available up to 1998, the cap was raised to 9p/kWh across the board, with some wind projects receiving up to 11p/kWh.

The desire to maximise the income from the first two NFFO rounds before its curtailment in 1998 led to attempts to hurriedly establish generating capacity. This, in turn, led to a number of clashes over planning permission, and this to the imposition of relatively harsh restrictions on applications for planning permission with regard to wind energy projects.

The same haste factor also led to a number of projects being developed which were to prove uneconomic, and to financial and organisational problems, which, with a greater amount of time available, may have been avoided as wiser counsel and more preparation prevailed.

In terms of helping to develop a British wind turbine manufacturing industry, the first two rounds of the NFFO were almost entirely unhelpful. The rush to take advantage of the subsidy overwhelmed the capabilities of the only British company producing wind turbines at the time, the Wind Energy Group (WEG). The result of this was that 345 out of the 415 turbines constructed as a result of NFFO-1 and NFFO-2 were manufactured by non-UK manufacturers (DTI 1995), primarily those which already had experience in the field. Thus the early renewables NFFO rounds acted not too help to develop UK industry, but rather as a subsidy to the growth of the industries of its competitors.

The official position of the UK Government on industrial policy for renewable energy was stated in 1995 to be that “the NFFO process does not provide a privileged position for UK equipment suppliers, but the Government believes that this is as it

should be. Suppliers must be able to compete in world markets if they are to succeed so, ultimately, it does not help to protect them at home” (UK Welsh Affairs Committee 1995). This statement made in the Government’s response to the Welsh affairs Committee’s second report on Wind Energy.

The statement could be interpreted as almost a direct reproof to the suggestion in the Committee’s report, that the early rounds of the NFFO were structured such that it was “doubtful whether there is a much more effective way of flooding an industry with imports than compelling all developments within that industry to be constructed within a very tight time scale, at a time when the domestic industry is both in its infancy and effectively tied to a single developer” (UK Welsh Affairs Committee 1994).

The Government policy statement is an interesting one. Its seeming belief that an industry should be able to develop from nothing, without assistance, if it is ever to be able to survive, is unusual. It would also seem to be at odds with Government policy in a number of other fields and to ignore the willingness of competing nations to support their own industries for their own national gain, and thus by implication, at the cost of UK industry, or potential UK industry.

The reality, as has been demonstrated elsewhere on many occasions in many industries, and as has been shown in previous chapters specific to the wind turbine industry, is that protectionist measures are often necessary to establishing national industries.

In terms of interpreting the policy, the nature of the arena in which it applies means analysis is not straightforward. The nature of international trade is such that all governments prefer to appear to apply trade policy which is open and fair to all actors, regardless of the reality. Thus, policy statements such as the one above might be

regarded as typical of how policy relating to many industries should appear, and do not necessarily have to represent the actuality of policy in action. Notably however, if protectionist policy is to be instituted, it is perhaps easier to say nothing on the matter, and leave a commitment to transparency as applying implicitly. This, however, is to equivocate - the simplest way to judge the intentions of the UK Government is through its actions on policy.

In real terms, the NFFO provided some support to UK companies simply as a result of the fact that it created opportunities for projects and thus for business. In doing so however it also created far more opportunities for companies from outside the UK. It thus allowed competitors business and construction experience to grow, as well as providing experience of operating in the UK market and increased familiarity with the particular issues relevant to it.

Obviously there are a number of advantages for a company operating in its home market, and any increase in the size of the domestic market should benefit the domestic market to a greater proportion than non-domestic industry. A wind turbine manufacturing company, for example, should be able to compete more effectively in its home market and gain a greater share of the market than would be the case outside that market. In an industry such as wind turbine manufacturing, wherein the product is a bulky one, geographical closeness to the market is generally an advantage.

The structure of the initial rounds of the NFFO impacted on wind turbine manufacturing such that British industry did not have the production capacity to meet the needs of the market, with the inevitable result that sales went to international competitors. Thus the singular advantage available to the UK industry was effectively removed.

The Government has often repeated the assertion that help would be provided to renewable energy only for research in technologies likely to lead to the “encouragement of internationally competitive industries”. Alongside this, the statement favouring the lack of preferential treatment for the wind energy technology industry would appear to remain as the official policy of the UK Government, though it remains unusual to see it spelt out so baldly. It is important to note however, that the nature of protectionism is such that, whilst it is easy to make statements condemning protectionist policies, it is politically difficult to make statements announcing that such a policy has been reversed. Thus a policy change in this matter would instead have to come from analysis of any new policy and of any effects it might have.

The statement can be seen as a reflection of the UK’s commitment to liberalising its electricity supply industry. Though it is difficult to marry a commitment to keeping protectionism out of the UK wind industry when the application of such policies has been generous in other industrial sectors, and when sectors such as the nuclear industry have been so heavily subsidised.

The prevailing political philosophy of the UK Government was to continue to shape the further rounds of the NFFO. The third round of the NFFO was announced in 1993, and introduced a number of changes. Most notably, the Government had by this time relented and allowed the renewable and nuclear segments of the Obligation to be separated. This led to the removal of the EC’s restriction limiting the application of the subsidy to eight years, and allowed payments to be made over a fifteen year period, thus reducing the capital cost to electricity produced ratio and effectively dropping the costs of obtaining capital at a stroke. A buffer period was also introduced which allowed projects up to four years to set-up for contracts within

NFFO-3, and five years within NFFO-4 and NFFO-5. Projects would then become able to claim the subsidy for the full period of fifteen years from the point they began generating. Thus many of the problems created by the over hastiness that accompanied the first two tranches were able to be avoided.

Greater experience among the developers, as well as falling turbine costs, meant overall falls in project costs. These factors, combined with the fact that projects accepted for contracts were paid their bid price and not a – usually higher – strike price meant that there was a significant reduction in the price paid for electricity generated under NFFO-3 than had been the case in the previous two rounds. A trend which continued with both NFFO-4 and NFFO-5.

On the basis of these falling prices, the Obligation can be regarded as a success, in terms of having achieved the goal of reducing the prices of renewable energy projects in the UK. The NFFO can also be regarded as partially successful in terms of achieving a minimum level of installed renewable capacity, though the main UK target of 1500MW in place by 2000 has not been achieved.

Clearly, the difficulty in meeting this target can, to a large extent be laid at the door of a planning system which acted as a constant barrier to effective growth of wind energy usage in the UK throughout the period of the NFFO, up to the present day, and may continue to do for some time into the foreseeable future.

The failure to meet the 1500 MW target however, may, at least in part, be a reflection of the 4/5 year buffer zone introduced with NFFO-3. This tends to encourage developers to wait until the end of the preparation period in order to maximise cost reductions, the result is a longer lead-in period than might otherwise be the case. With typical development times of 2-3 years for a successful project to move from proposal to installation, this means a further slowing to the rate of increase

of capacity contracted under the NFFO. This is hopefully a condition that will not apply under the RO.

The comments of the Welsh Affairs Committee quoted above underline the reason why the first two rounds of the NFFO mechanism were poorly thought out in terms of helping to stimulate UK industry in turbine manufacturing. It is apparent however, that the remaining three rounds also failed to stimulate a significant industry. One contributing factor to this failure reflects another aspect of the NFFO which was deficient to such stimulation. NFFO rounds took place in 1990, 1991, 1994, 1997 and 1998. That is to say, even with a commitment to a bidding process to take place in discrete blocks rather than on a rolling basis, there was no continuity as to when the orders were made. The obvious effects of this were to reduce the level of security inherent in the field, and to raise the perception of risk for potential investors.

Effectively, the UK market lacked the security needed for domestic companies to risk setting up, whilst still providing opportunities for sales to non-domestic companies which has already had the chance to prosper in their own home markets.

Mitchell (Mitchell 2000) highlights that actual installation of projects within the third round of the NFFO seem certain to fail to meet the DTI benchmark, which assumes capacity equal to around 50% of the contracts awarded will be actualised. Contracts awarded under NFFO-3 reached the end of their four-year development period on December 31<sup>st</sup> 1998. Any projects not generating at this point were effectively losing part of their fifteen years of premium payments, and are thus increasingly unlikely to move to completion. Mitchell suggests that “it would be hard to think of more supportive contracts than those awarded through NFFO-3” (Mitchell

2000), but notes that only 40.6% had been commissioned. This shortfall in commissioning can be traced directly to problems in acquiring planning permission for projects awarded contracts under NFFO-3.

Table 7.2 Status of planning applications (PA) for wind energy projects

		<b>Live (MW DNC)</b>	<b>Submitted PA (MW DNC)</b>	<b>No progress (MW DNC)</b>	<b>Refused PA (MW DNC)</b>
NFFO3	Contracts 18	44.74	45.63	38.39	33.47

(Mitchell 2000)

The fact of the NFFO's existence has a number of implications in terms of the mechanisms which could otherwise have been employed, and the aims which would have been implicit in their use. It also has significant implication in terms of the statement it makes concerning the attitude of the UK, and its Government, as regards the development of renewable energy and the industries involved in it.

The particular structure of the NFFO led to a number of constraints on the growth of renewable energy in the UK. Possibly the most evident of these is that it limits support to a specific range of technologies. Those technologies that are assessed as being insufficiently close to achieving market readiness are not supported. This engenders a further problem. The level of industrial input of R&D funding foreseen by Energy Papers 55, 60 and 62 has never materialised. According to the UK Government this is because funds are instead being used for the financing of projects within the NFFO. Until the late 1990's the level of public funding was in decline, "the UK R&D program fell from a high of £25 million in 1992 to a low in 1997 of just over £11 million pounds. It has been increasing since then and will reach £18 million in 2002" (Mitchell 2000). Combined with the almost total lack of private funding for such purposes, this meant that the level of support for those technologies furthest from being competitive was extremely low. Thus the NFFO effectively



locked the UK's efforts into the technologies already close to market readiness. Other technologies, including PV, which were not included in the NFFO are not significantly supported, and thus have considerably less stimulus to towards being competitive. Thus, such technologies are rendered less likely to become viable industries at all, both fractionally at the global level and, perhaps more pertinently to this research, at the level of UK ownership. This focus on the technologies close to market readiness would appear to be the intended policy of the NFFO. Mitchell points out that Energy Paper 62 'makes clear that the NFFO is a market enablement mechanism intended to support near-market technologies' (DTI 1994; Mitchell 2000).

Whilst recent policy documents have made provision for an increase in R&D funding, the amount available compares poorly with competitors such as Germany, though the UK government has committed to making a 150% tax credit available to SME's spending more than £50,000 per annum on R&D as part of the Finance Act (2000), incidentally, the same piece of legislation which granted renewable energy an exemption from the Climate Change Levy. The tax credit is effectively equivalent to a 30% reduction in R&D costs (DTI 2000d; HMSO 2000).

Success in wind turbine manufacturing in both Denmark and Germany has been characterised by being centred around smaller enterprises, those companies which have attempted to access the market in the UK have been subsidiaries of larger concerns. The UK has historically experienced considerable problems with regard to the prosperity of its small business concerns. While many such companies are initiated, their success rate is low in comparison to most of the UK's European competitors. The result is a lack of specialisation by these companies and a lack of the tendency observed in a number of industries wherein groups of competitive, highly specialised companies – known as clusters – act to support an industry and its

development and advancement. This problem was exacerbated by the introduction of the 'enterprise' concept as the focus for British efforts at stimulation of its economy. The actualisation of the concept was aimed at increasing entrepreneurial investment in any kind of business opportunity, rather than having a focus on the higher technology opportunities that Walker identifies as the focal point for most other countries efforts in that direction. Walker also notes the comparative weakness of indigenous UK companies in high- and even middle- technology areas, particularly amongst the large multinational level companies (Walker 1993).

The UK's preference for maximising the level of competition led to the particular structure of the NFFO. It may also be regarded as preventing a number of other methods of support from being used, for example the provision of "capital grants, low interest loans, loan guarantees and other forms of capital underwriting" (Elliott 1994). All of these, it has been suggested, might help to increase deployment in those technology bands which may not need substantial R&D but could benefit from cheap financing. Again the knock-on effect of this is to reduce the chances of developing new technologies and thus the opportunity to exploit the potential market for those technologies.

It should be noted that alongside the NFFO, which was the instrument for development in England and Wales, parallel instruments were also in place for Scotland and Northern Ireland. "As of 31<sup>st</sup> March 2000, the [Scottish Renewables Order] SRO and [Northern Ireland Non-Fossil Fuel Obligation] NI-NFFO have awarded 336 and 32 MW DNC of contracts, respectively, with 48.11 MW DNC and 17.5 MW DNC commissioned" (Mitchell 2000). The SRO will be replaced with the Renewable Obligations (Scotland) (ROS). A decision has yet to be made as to the support mechanism for renewables in Northern Ireland (DTI 2001a).

### 7.5 The Present Status of Wind Energy in the UK

By the end of 1997, 320 MW of wind energy capacity had been installed in the UK. Almost all of it established as a result of contracts offered within the NFFO and the majority of it in the ownership of major investors such as the REC's, large scale generating companies and others such as Yorkshire Water. Notably, by the end of 2000, the total installed capacity had risen to only 409 MW. In the same period, 1997-2000, German capacity expanded from 2080 MW to 6113 MW, and Danish capacity from 1116 MW to 2297 MW (WPM 1998; WPM 2001). The various rounds of NFFO competition have produced variable results. NFFO-1 awarded nine contracts for large scale wind energy projects, eight of which came to fruition, with the installation of 11.7 MW of capacity. NFFO-2 awarded forty nine contracts, twenty three of which reached the construction phase, for a total of 47.15 MW of capacity (Mitchell 1995). Contracts for a total of 165.63MW declared net capacity (DNC) of wind energy were awarded as a result of NFFO-3, (Mitchell 1995; Lindley 1996) and 339.7MW DNC awarded from NFFO-4 (Massy 1997). The most recent tranche, NFFO-5 awarded contracts for 368.08MW DNC of wind power (DTI 1998). This fifth round of the NFFO, the last within the NFFO mechanism due to changes in the structure of the UK's energy supply system, also saw the prices for some of the larger projects achieve what could be regarded as approaching convergence with the market price of electricity, though the average price remains slightly higher. This development can, at least to some extent, be regarded as something of a vindication for the mechanism. However, Mitchell points out two scenarios which may indicate that the prices are not as low as the raw figures indicate. Firstly, some of the lowest bids rely on projected prices based on predicted falls in costs over the four/five year development period. Secondly, in the absence of any penalty clauses for unfulfilled

contracts, Mitchell suggests the possibility that some companies may have made bids to secure contracts, rather than lose them to competitors (Mitchell 2000). Both of these scenarios open the possibility that the successful bids made in the NFFO-5 tranche were not completely realistic reflections of the prices that can be achieved for wind energy in the UK. Nevertheless, it is undoubtedly true that the NFFO did act to reduce the costs of exploiting wind energy in the UK.

Bids which successfully won contracts under NFFO-5 are still likely to face significant barriers to deployment, most notably with regard to rejection at the planning stage, often based on out-of-date criteria applied to judging the usefulness and impact of the technology, according to the Royal Society (Royal Society 2000; Royal Society 2001).

#### 7.6 The Renewable Obligation

The development of the utilities bill in the UK, and its final assent on 28<sup>th</sup> July 2000, signalled the end of the pool price system for the UK electricity supply industry, and introduced the so-called New Electricity Trading Arrangements (NETA) (OFGEM 2000). The introduction of NETA meant that the NFFO – which relied for its pricing system on the average pool price – could not continue as it had since its adoption as part of the 1989 electricity privatisation. Though the coming of this change was foreseeable for a number of years before passing into law, the process to introduce new policy on renewables in the UK was a tortuously slow one.

After a number of delays, the Department of Trade and Industry (DTI) published a consultation paper regarding future UK renewable energy policy in March 1999 (DTI 1999). This essentially reiterated, in general terms, the reasons for wishing to develop RET's. It assessed the status and prospects for the use of the different renewables energy technologies in the UK. It then laid down the options for possible

future support mechanisms that might be employed to support renewable energy use in the UK. Suggested mechanisms were to consider ‘a variety of possible aims’, which were to include

- assisting the UK to meet national and international targets for the reduction of emissions including greenhouse gases;
- helping to provide diverse, secure, sustainable and competitive energy supplies;
- stimulating the development of new technologies necessary to provide the basis for, and continuing growth of, the contribution from renewables into the longer term future;
- assisting a UK renewables industry to become competitive for home and export markets;
- assisting to provide employment in a rapidly expanding sector.

(DTI 1999, pp33)

The discussion of possible mechanisms for the continued support of renewables is actually limited in the document however. It discusses the potential for a 10% target for renewable energy generation by 2010 without committing to it as a policy. Furthermore, the prospective costs of such a policy are not specifically addressed. Particular options for mechanisms that are addressed include;

- energy taxes and emissions trading;
- a scheme to stimulate a market for renewably sourced electricity;
- direct grants.

(DTI 1999, pp55)

Predictably, but still worthy of noting, the second of these, the scheme to stimulate a renewable electricity market, is specified as having to itself be market-based. The possibility of the use of a renewables obligation is specifically raised in the document. That is, an obligation on consumers or suppliers to have a certain percentage of their electricity mix derived from renewable sources, what might otherwise be known as a Renewables Portfolio Standard (RPS) (Rader and Norgaard 1996).

What is most notable about the document in this context is perhaps not what it includes but what is missing. The potential use of a REFIT-type mechanism is not raised as being worthy of consideration. This is perhaps not totally unexpected given the UK commitment to market forces enshrined in the use of the NFFO mechanism, and in the general disposition of the UK electricity market. It could, however, be regarded as overlooking the success that the REFIT mechanism has had in those countries where it has been adopted, and the continued uptake of REFIT mechanisms in countries wishing to develop renewable energy, and wind energy in particular.

The responses to the consultation process, along with the conclusions drawn by the government were published in the January of 2000 (DTI 2000b). The conclusion of the government was that the UK should move away from the NFFO mechanism and, perhaps unsurprisingly, adopt a renewables obligation as outlined in the earlier document. It also announced the intention for a further consultation to take place before the final publication of Government plans later in 2000. The Energy Minister at the time of publication of the document, Helen Liddell, underlined this codicil with a statement that “It’s time to make the next generation of [renewable energy] technologies lean and mean as well as clean and green” (DTI 2000a).

In order to ensure this end, the effect on the nature of the mechanism was the likely imposition of a cap on the prices electricity suppliers will have to pay for renewables to fulfil their obligation. The paper estimated that to achieve the 10% target would require an estimated 36-39 TWh of electricity from renewable sources by 2010. It further estimated that this would require an increase in annual production of 20-23 TWh in excess of that likely to be produced from renewable generators already in place, and from those likely to be established under NFFO-3, 4 & 5. The Government also committed to paying out the full fifteen year of contracts awarded in these three rounds.

The paper also announced that renewables would be excluded from the climate change levy (CCL) to be imposed on industrial energy use in the UK. The CCL, introduced from April 2001, places a charge of 0.43p/kWh on all electricity sales to business customers. Eligible technologies for this exemption were to include most of the new renewables, though hydro plants above 10 MW of capacity and waste-to-energy generation would not be included. Generators which had been developed under the first two rounds of the NFFO were proposed to be eligible within the obligation

Additionally, the government committed to increased support of RD&D, including the provision of assistance to industry to develop export capabilities and the facilitation of regional planning structures and targets for renewables.

The Utilities Bill laid down the use of the mechanism as a statutory instrument such that it could be used to place an obligation for England and Wales and a separate obligation for Scotland (DTI 2000b). The RO will require its own bill to actualise it, this is expected in late 2001.

In the October of 2000, the UK Government produced a further document, The Renewables Obligation Preliminary Consultation (DTI 2000c). This document detailed changes to the earlier proposed Government policy resulting from the feedback received from the report earlier in the year. It confirmed the likely structure which legislation would put in place for the running of the obligation, and requested feedback on its proposals from interested parties.

It confirmed that the intended obligation would not have bands for different technologies, but that suppliers would be able to seek out the cheapest option from those technologies classified as eligible, in order to fulfil their obligation. Thus the central policy for expansion of renewable energy usage in the UK would be firmly based on competition. The then Secretary of State for Trade and Industry, Stephen Byers, stated that the policy of the DTI would be “one of action but not of direct intervention” (DTI 2000c, pp3).

Basically, the RO as it was proposed in October 2000 was quite simple. Each licensed electricity supplier in the UK would be subject to “a legal obligation to supply a specified proportion of their electricity supplies from renewable energy sources to their customers in Great Britain” (DTI 2000c, pp13). Suppliers would need to offer proof of their compliance to the regulator, OFGEM. They would also have a choice about how they fulfilled their obligation.

Suppliers demonstrate their compliance with the RO through the production of Renewables Obligations Certificates (ROC's). These can be earned through the supply of renewable energy purchased from generators, or alternatively could be purchased independently of their energy use. Suppliers are also able to sell any excess ROC's to other suppliers.



The third option for suppliers to fulfil their obligation – and effectively the default option – is payment of the buy-out price. Companies unable, or perhaps unwilling, to find sufficient ROC's to fulfil their quotas are obligated to pay this price for every kWh of renewable energy they fall short of the RO specified fraction of the total energy they supply. The figure proposed for the buy-out price in October 2000 was 3.0p/kWh, with the government proposing that the figure be linked to the retail price index. Suppliers may pass on all costs of complying with the RO to their customers. The buy-out price acts as an upper limit on the amount that has to be paid out to finance the increased use of renewables, and limits the burden that must be passed on to the consumer. The report also estimates that the total cost to the consumer by 2010 should be in the order of £600 million for that year, equivalent to a rise of 3.7% on 1998 prices.

The report also contains figures for the projected gains that the UK Government hopes to achieve by 2010. See Table 7.3.

The consultation document also confirmed that the obligation was intended to be in place from October 2001, until the March of 2026, thus making it one of the longest term commitments to the support of renewable energy devised in any country.

Clearly, the adoption of a policy which removes the use of technology banding in favour of a completely open market, could mean the end of development for any technologies not market ready. To offset this, the DTI proposed that grants would be made available to support an initial round of offshore wind, and of energy crops. Whilst the document lays down that offshore wind projects will be able to claim up to 40% of their costs under such a grant scheme, somewhat oddly it fails to explicitly state what amount of funds are available for these grants. Rather, the only mention of the level of funding is the statement that "A limit of £10 million per project would

allow at least four projects to be supported” (DTI 2000c, pp51), implying an upper limit for availability of £40 million.

Table 7.3 Profile of the Renewables Obligation to 2010

	Estimated Sales by Licensed Suppliers	Estimated Consumption by auto generators	Estimated Losses	Estimated Total Electricity Available	Renewables Target (to reach 10% in 2010)	Contribution from Non-Eligible Renewables	Contribution from Eligible Renewables Required	RO as % of Sales
	TWh	TWh	TWh	TWh	TWh	TWh	TWh	%
1999	300.5	21.2	29.1	350.8		6.0		
2000	301.9	22.0	29.3	353.2		5.9		
2001	304.0	22.5	29.2	355.7		6.3		
2002	306.1	23.0	29.0	358.2	16.1	6.7	9.4	3.1
2003	307.9	23.9	28.9	360.6	18.0	7.0	11.0	3.6
2004	309.7	24.4	29.1	363.1	20.0	7.5	12.5	4.0
2005	311.8	24.9	28.9	365.6	21.9	8.0	13.9	4.5
2006	314.3	25.5	28.7	368.5	25.8	9.0	16.8	5.3
2007	316.4	26.4	28.6	371.4	29.7	10.0	19.7	6.2
2008	318.9	27.0	28.4	374.3	33.7	11.0	22.7	7.1
2009	321.4	27.6	28.3	377.3	35.8	12.0	23.8	7.4
2010	323.6	28.1	28.5	380.3	38.0	13.0	25.0	7.7

(DTI 2000c, pp19)

In April 2001, the Crown Estate approved pre-lease qualification for developers of the eighteen offshore sites identified by the UK Government as being desirable for siting (Rajgor 2001).

The grants, while they may help to stimulate a small number of projects within the technologies to which they apply – and the document makes clear this is an intentionally small number – still give rise to at least two problems. The amount of capital they make available is quite small, a fact which the Renewables Obligation Preliminary Consultation document acknowledges. The other, perhaps more serious, problem is that it still leaves some technologies outside the scope of funding to stimulate their use, as well as leaving them unlikely to be competitive enough to

feature in purchases within the RO. Technologies which may be excluded include PV, wave and tidal energy technologies, though PV may receive some funding from an additional £100 million allotted to RE research as part of the UK Government's 2001 budget (RIIA 2001). Additionally, whilst the long term commitment to the development of renewables in the UK is to be welcomed, it seems natural that those technologies which can not compete initially are only going to increasingly lose ground on those that can, and thus be increasingly unlikely to be taken up within the obligation. Potentially, this might effectively write them off.

The introduction of grants at all is a break with past UK policy. Energy Paper 55 noted that 'Some countries have in the past tackled the institutional issues head-on by offering financial incentives in the form of grants or tax concessions in order to stimulate deployment. While these can certainly accelerate the introduction of new technologies they can also be counterproductive if, for example, they are based on extravagant technical claims or if the technology is not yet fully developed. This approach is not favoured' (UK Department of Energy 1988). In practice this has tended to mean no grants have been available.

This reversal in policy regarding the use of grants as a tool for subsidising the encouragement of investment in less market-ready technologies is an interesting development. In the context of this research however, one aspect of grants which is particularly notable is their potential to be directed in a manner offering protection to domestic companies. The likelihood of this occurring is low however, given the historical patterns of support for renewables, and the nature of the electricity industry in the UK.

An additional factor that should be mentioned is that there is support for exports from the UK renewables industry, such as it is, from the DTI's New and

Renewable Energy Programme. This has two trade promoters who exist to aid UK RET businesses to identify and exploit new opportunities in overseas markets.

### 7.7 The UK Wind Turbine Manufacturing Industry

The historical lack of support for UK manufacturers inherent in the UK's policy regarding renewable energy is more than apparent in the state of its wind turbine manufacturing industry. Those companies that exist produce goods on only a small scale. As of January 2001, there were no established UK-owned manufacturers of large turbines, though the developer Renewables Energy Systems, a subsidiary of McAlpine Group, has been carrying out pilot studies with a 1MW turbine in Northern Ireland, and hopes to move towards commercial manufacture (Shears 1999; BWEA 2001). The last two significant UK manufacturers, the Wind Energy Group (WEG) and Taywood Aerolaminates, respectively turbine and blade manufacturers, and both previously owned by Taylor Woodrow, were sold to the Danish company NEG Micon in March 1998. The Danish company also became the world's biggest selling wind energy equipment manufacturer in that year. The acquired companies continue to produce goods in the UK, and thus some of the economic benefits associated with their operation will accrue to the UK, in terms of employment and investment. Profits however, accrue to the Danish owners. WEG, now operating under the name NEG Micon UK remains the only manufacturer of large wind turbines active in the UK (Massy 1998).

There are a range of reasons underlying the lack of an established wind turbine manufacturing industry in the UK.

As has been discussed at length in previous chapters, there is considerable evidence from Denmark, Germany, and now Spain, that a strong domestic market is essential to the development of a domestic industry.

The UK has attempted to stimulate such a market through the NFFO. The particular mechanism of the NFFO though, particularly in the early rounds, has undoubtedly worked against the development of a UK industry. Later rounds have proved to be irregular and orders slow due to barriers such as planning problems, offering little in the way of security to potential industrial investors. Perhaps more importantly, there has been very little policy directed to specifically aiding UK industry, as the UK Government has refused to direct assistance to the sector. Even without policies in place to specifically enable the growth of a British wind turbine manufacturing sector though, there are still a range of other barriers to the growth of renewable energy usage, the domestic marketplace, and thus domestic industry. UK policy on renewables has failed to address many of these, retarding the creation of a domestic market, and thus of a domestic industry.

### 7.8 The Role Of the UK's National Innovation System

The many barriers to the growth of renewable energy usage in the UK have been detailed in depth in a number of forums, as noted in Chapter One. The potential for the growth of a UK wind turbine manufacturing industry, as in other countries, is also heavily affected by the particular national innovation system (NIS) in which it would have to develop.

The UK NIS has a number of features pertinent to the possible establishment of a significant domestic turbine manufacturing industry.

Perhaps the most significant aspect of the UK's NIS with regard to the development of a wind turbine manufacturing industry is the national finance system

(NFS). Both Mitchell and Lindley (Mitchell 1994; Lindley 1996) have addressed the details of the UK's NFS and its applicability to industries in the renewable energy sector. Mitchell details the difficult path which companies must follow to obtain finance for projects.

The first step is to obtain senior debt capital – that is, that portion of the capital which has the first claim on revenues – which is guaranteed and therefore not risk capital. Thus the more debt capital that can be obtained from financial institutions, generally banks and building societies, the better for the developer. Next, equity capital must be established, this is provided by the developers themselves as a form of guarantee to secure the loans necessary for the project. This is risk capital and the last part of the capital invested in a project that will be repaid – if it is repaid at all.

Mitchell points out that part of the equity may also be obtained in the form of subordinated debt from a third party which acts to reduce the overall cost of the project by placing an extra layer of debt between the debt capital and equity. The availability of capital will obviously be dependent on the levels of risk apparent in a project. The existence of mechanisms which act to reduce the level of inherent risk allow capital to be more easily obtained. The NFFO acted to significantly reduce the risk of projects by guaranteeing a minimum level of sales and thus of income, though the original eight year limit imposed on NFFO payments had the effect of diluting this to some extent. Outside of the NFFO, financing of wind energy projects has largely been regarded as being too high a risk to obtain financing, though in recent years a few projects have managed to finance themselves from alternative sources. The introduction of the RO in the UK is likely to have implications both regarding the creation of a domestic market for wind turbines, and for the potential creation and

operation of a domestic industry within that market. These implications will be discussed later in this chapter.

Lindley records that the majority of the projects awarded contracts under the first three rounds of the NFFO have been financed through one of two methods;

- “‘Balance Sheet Finance’: where the cash resources of a company have been used to finance the entire project, or where bank loans have been secured against other parts of the business, or major assets or personal guarantees have been given, this is often linked to property owned by the developer.
- ‘Limited Resource Project Financing’, where bank loans are secured largely against future cash flows, as well as against the physical assets of the project being financed.”

Either method typically sees most of the necessary capital obtained from banks loans, with the major difference being the security arrangements of the lender.

Obviously, the controlling factor in the availability of these loans is the perception of the risk by the lender. It is the job of the developer to reduce the perceived risk in order to minimise the cost of the loan. The perception of the risks associated with making such a loan can however also be affected by the degree of success of those projects that have gone before (Mitchell 1994; Mitchell 2000). The nature of the NFFO has meant that banks have appeared to lock themselves into providing loans which will take into account revenues only from the running time of the NFFO contracts, indeed this was one of the major problems with the original eight year limit placed on contracts. The increase to fifteen years made finance easier to attract for obvious reasons. It remains possible however that because the experience of the banks and other lenders is, in most cases entirely confined to projects within the

NFFO, and their experience of developing projects outside of this context is so limited, leads to a perception that the risks of such projects are greater than is perhaps the case. The success of those few projects that are beginning to emerge that have found funding outside of the NFFO, may have significant implications for the way in which other new projects are viewed in the future and for the possibilities of growth for renewables outside of the restrictive perimeters of the NFFO.

The major problems in the UK's financial system, as identified by Mitchell (Mitchell 1994), are both that there have been only a comparatively small number of sources of equity, particularly of 'alternative' sources of equity such as ethical banks, and that those sources that do exist are more applicable to larger projects. That is, the majority of renewable energy projects tend to be too small to warrant their attentions. Mitchell further identifies the comparatively unusual quality of the UK NFS in tending towards higher rates of return or dividends on the equity portion in comparison to the bank loan, thus the costs of the project are raised above the level they would exist at, in, for example, the Netherlands or Denmark.

Mitchell identifies venture capitalists as providing an established alternative to banks as a source of equity in the UK. Simply, these provide investment in companies with the expectation of capital gain based on the future increased value of a project, in addition to the annual dividends. The nature of renewable energy projects on the whole, and certainly in the context of the NFFO, whereby revenues over the lifetime tend to be well known and profits tend to accrue towards the end of the project, is unattractive to this form of investment.

Mitchell also notes the existence of 'Green Funds' in the UK, which supposedly exist to provide a source of investment for 'green' projects, but points out that it can be as difficult, or even more difficult, to obtain capital from these than from



commercial banks. Since 1994 the actions of the Triodos Bank, a Dutch ethical investment bank, in the UK mean that this situation has changed slightly, as a small number of wind energy projects have been financed through such schemes, which also offer the smaller investor the chance to get involved in wind. (Triodos 1998) Triodos provided the funding for the Haverigg II development after issuing shares to meet the funding needed for investment.

The DTI, alongside a number of charitable organisations, is also currently investigating the potential for community involvement in financing wind projects through the Awel Aman Tawe project in Wales. The project involves investigating whether the local community actually wants wind turbines in their locality, based on having all the facts about what such a development would involve, both positively and negatively (AAT 2001).

The UK's energy minister from 1997 to 1999, John Battle, expressed enthusiasm for the increased community financing and ownership of wind turbines in the UK. So far however, only two community owned projects have been developed in this manner. NFFO-5 may offer the opportunity for this number to increase given the large number of small projects given contracts.

The result of all this is that there is no aspect of the UK NFS which is particularly apt for the effective support of any effort to expand the renewable energy capacity of the UK outside of the heavily guaranteed projects accepted into the NFFO. The clear lack of any significant projects outside of the NFFO would seem to indicate that this is the case.

Mitchell also proposes a number of possible solutions to the problems of providing financing to the typically small renewable energy projects. These include non-recourse project financing, and the possibilities of bundling a number of projects

together. Bundling perhaps 10-15 projects, each with a value of around £300,000, and signing a common contract to provide financing for all of them, might achieve the rough level at which it becomes easier to attract support within the UK's financial system. However, neither of these could be regarded as ideal methods of providing support.

Mitchell also addresses the possibilities of matching up small projects with local branches of banks, but notes that this would be best aided by some form of encouragement from Government, to increase the level of confidence on the part of the bank.

This is to digress however, the problem of gaining access to equity capital is not confined solely to smaller projects. Mitchell advocated a number of initiatives that could be pursued by the banks, REC's and other actors in the field to increase the level of access. The main measures however, Mitchell suggests, would have to be on the part of the Government, and lists a range of possible policies for increasing investment interest in renewables generally. These included;

- Education for bankers;
- Financing and organisation of advertising for investors as an exemption from the Financial Services Act.;
- Publishing of data regarding equipment reliability within the NFFO;
- Government financial support to relieve banks of the additional costs of initiating new loan schemes for renewables;
- Government loan guarantees to local banks covering the first few loans given to RE projects;
- Simplification of the NFFO process;
- Encouraging standardisation of contracts between actors to reduce costs;

- Examination of the possibilities of utility bonds or green tariffs;
- Examination of the possibilities of tax breaks for those investing in renewable energy.

Since these suggestions were put forward in 1994, the NFFO has given way to the RO, apart from this change in the support mechanism however, very little has changed with regard to the above list. The provision of grants for some technologies in 2001 goes some way to addressing the need for financing for those specific technologies. The RO itself has not progressed far enough that it is possible to speculate too widely as to what effect it is likely to have on financing, though it would seem likely that a new mechanism might suffer from some problems. Firstly, relating to the unfamiliarity of investors and bankers with the new mechanism.

Secondly, a possible problem with the RO may arise from the provision of contracts within the obligation mechanism. It is too early as yet to conjecture as to what length of contracts suppliers attempting to fulfil their renewable supply obligations will offer. It seems likely that they will have to balance the desire to continue to minimise their costs on an annual basis against the needs of the generator to be able to secure financing where this is dependent on achieving some guarantee of minimal contract length in order to borrow at competitive rates.

The use of green tariffs has also been effectively instituted as part of the continuing deregulation of the UK's electricity supply industry.

There are other aspects of the UK NIS which have the potential to impact on the creation of renewable energy manufacturing, and wind turbine manufacturing in particular, in the UK.

The record of the UK with regard to financing of R&D generally, and the effect this has on the UK's ability to develop competitive technology, has received criticism from a number of sources. Walker (Walker 1993) notes the declining investment in R&D in the UK in comparison with Germany, France, Japan and the US. This decline being largely in that portion provided from the public purse. While this drop, which was intended to stimulate greater private funding to shift the burden of paying away from the taxpayer, has acted to increase the level of privately sourced expenditure, this has largely come from companies based outside the UK. Whilst this leads to some economic benefits for the UK, it also means that the results of the research are under the control of overseas companies. Within this context, the drop in R&D funding for wind energy research, and for renewables in general, is to be expected. The negative impacts of reducing R&D funding have already been discussed in chapter three. Specifically, the fact that the British turbine manufacturing industry has been too small to afford significant investment in R&D, has perhaps led to a self-reinforcing cycle wherein no real investment takes place, and thus the industry has no opportunity to compete effectively. The lack of funding can be linked to the NFFO which, it has been suggested, has acted to absorb the funds which would otherwise have gone into R&D (Elliott 1994). If this is accepted to be true then the presence of the novel funding mechanism can itself be regarded as erecting a further barrier to the development of a UK industry.

The UK's NIS is also marked by poor integration and poor co-ordination between most of its actors. Walker outlines five separate problems concerning such co-ordination, these include;

- Integration of Scientific and Technological Communities;

That is, the contacts between those doing scientific research and those trying to actualise knowledge into useful technology are notably weak in the UK, Walker specifically highlights one cause of this as being the lack of ‘bridging’ institutions which exist in the UK.

- Organisation of R&D and Product Development;

Considerable amounts of R&D funding have gone to large-scale high-tech projects, which frequently turn out to be wasteful and disappointing. While Walker notes that that this phenomenon is far from unique to the UK, he suggests, though without presenting evidence, that Britain’s record is amongst the worst. He posits that this is due to particular problems in coping with the high levels of complexity inherent in such R&D.

- Producer-User Relations;

Good relations of this type are rare in the UK, thus allowing easy penetration of UK markets for foreign companies. Walker also mentions the traditional British consumer of purchasing goods freely, rather than showing specific loyalty to British products.

- Managerial Co-ordination;

Walker draws three points from what could be a far more extensive list, these are the hierarchical, rather than participatory, nature of British management, problems of cross-divisional co-ordination endemic to British management, and finally, the comparatively poor performance of British companies as they get bigger.

- Banks and Industry;

There is a distinct lack of co-operation between British banks and industry in comparison to many of its competitors. This would appear to stem from a fear of reducing the level of flexibility within the economy, though this is not always an advantage. The emphasis on the use of the free market as the primary method of co-ordination, prevalent since Thatcherism, and emphasising individual competition, is unlikely to lead to an increasing level of co-operation.

Walker analyses the relationship between the UK government and the UK innovation system and suggests that historically the UK government has not regarded itself as an agent for the stimulation and generation of new modes of production. A stark contrast to, for example, the German approach to industrial policy. Walker also notes that, while at some points the level of government interference has increased, notably after the second world war and through to the 1970's, with attempts to increase the level of co-ordination between unions, government and industry. The results of this however were only a very low degree of success in terms of the projects it engendered. The response to this came in the 1980's with the removal to the greatest extent possible of any of the mechanisms aimed at managing the economy by the Conservative Government. The Labour Government elected in 1997 has not displayed a general inclination towards increasing efforts at managing the economy, though there are some exceptions to this. The adoption of the RO indicates that the competition is still viewed as central to policy for driving the use of renewables, as with the NFFO.

A further historical problem inherent in the UK NIS, again identified by Walker, is the lack of co-operation that has taken place between the UK Government

and UK industry in post-war history, and the lack of stability that has marked this relationship. Walker suggests this is the result of the multiple switching between Governments with very different agendas as well as a failure to deal with economic decline. Obviously this has had an effect not just with regard to renewable energy technology manufacturing but across the board with regard to British industry as a whole. The affects of this factor on the advancement of renewables may actually be quite minimal due to their relatively recent emergence, and the unusually low level of switching between administrations that has occurred in the UK since 1979.

Whilst government-industry co-operation has been weak, that is not to say that the Government has not favoured particular areas to varying extents. A notable aspect of the UK political system in recent years is the political support given from either end of the political spectrum to specific operators within the energy sector. The sector has effectively become a battleground for opposing political ideologies. The Labour Party, traditionally heavily influenced by the trade unions has supported the coal industry, both politically and economically. With the eighteen year period of Government enjoyed by the Conservative Party from 1979-1997, it is Conservative policy which has come to dominate the UK energy mix. The results have been the – almost certainly irreversible – running down of the majority of the coal industry in the UK, a switch to electricity generation from gas, and enough support for nuclear-generated electricity that it has been able to be sold economically. The policy of running down the unions can be seen as another aspect of the ending of the strategy of attempting to manage the economy through a partnership of labour, management and the state.

Walker's point regarding poor co-operation between government and industry is an apposite one. As described in chapter four, the close relationship between the

Danish turbine industry and government has played an important part in ensuring that Danish policy supported both the growth of Danish wind energy use, but also aided the growth and development of the industry itself. This is a further condition which is absent from the situation in the UK.

The effect of all this was to render renewable energy technologies as very much a side issue. Actions to encourage movement towards the low installation targets set for renewable energy technology use could be used to portray a green image of government without any real political commitment to their development or even to achieving the targets themselves. The failure to achieve even the low targets would seem to justify this interpretation.

#### 7.9 Possible Applications of Danish, German and Spanish Policy in the UK

Whilst it would be unwise to imply that the Danish, German and Spanish models of industrial development with regard to wind turbine manufacturing are the only possible valid ones, it may be worthwhile to note qualities present in those models which are absent from the model in place in the UK.

The lack of any significant constituency with the capability, or the willingness, to support wind turbine manufacturing in the UK means that the industry would have to survive, and compete, without one of the major advantages of the industries of other nations also competing in the marketplace.

Strong green movements are firmly established in both Germany and Denmark, and play a significant role in mainstream politics. The large constituency they enjoy, and the ability to effect and influence policy, have no real equivalent in the UK. The green movements have had different effects in these two countries. Denmark has had a strong grass roots movement developing wind energy, and a wind



energy industry, to a large degree independently of the Government, but with a government very active in instigating environmental policy. Germany has had a strong politically active green movement influencing the direction of policy in Germany, though without the hands-on development that occurred in Denmark, and without renewables featuring as strongly as an important environmental issue. In the UK neither of these circumstances exist, the green movement enjoyed only minor success in UK politics, and while each of the major parties professes to hold environmentally beneficent policies, issues relating to the environment are generally not accorded a high priority.

In a similar vein the UK lacks the customer base for the purchase of wind turbines that enabled the initial growth of the Danish domestic industry. In a comparison with Germany however the situation is, in theory, quite similar. A large proportion of the turbines erected there in the last few years have been owned by farmers. They are seen as a way for the farmer to increase the income from his land. With the proper mechanisms put in place to remove some of the barriers to use, combined with education and information dissemination programmes, UK farmers could form the basis for a domestic customer base. For this reason, the UK special interest group, the Country Land and Business Association, formerly the Country Landowner's Association has supported responsible increases in the use of wind energy. Both Denmark and Germany now have 100,000 citizens with a financial interest in turbines, forming an economically motivated constituency with commensurate political influence, besides that of the environmental campaigners.

Toke (Toke 1999) goes as far as to suggest that it is essential for the UK to develop wind energy founded almost entirely on a system of community ownership as in Denmark and Germany. This however would seem to ignore recent Spanish

success in wind energy, where community ownership is not largely a factor. It also ignores many other factors which were at work in making wind a success in both Denmark and Germany. For example, the significant grass roots and mainstream political support for, and the historical use of, wind energy in Denmark, and the political set-up inherent in the creation of the German industry. Toke also fails to address the changed context of the industry since the Danish industry was established, and to consider the changes in operating conditions this may have created, and the factors which may have important implications for new entrants to the industry that did not apply in Denmark, but which would be important to the development of manufacturing in the present industrial circumstances.

A factor which further colours the nature of UK support for renewable energy technologies stems from the political direction of the UK. According to OECD figures, the UK is now both the least regulated product market in the developed world, and the nation which exhibits the least degree of state control over trade (OECD 2000). Consecutive governments have also consistently placed emphasis on maximising 'value-for-money' from those funds provided for the purpose of stimulating innovation. This has resulted in a demand for greater results in return for public investment, and this demand for increased efficiency led to the application of a range of incentivising measures. Funding linked to quantifiable returns has resulted in institutions switching funding to shorter-term projects, rather than risk having funds tied up in uncertain long-term projects. The majority of renewable energy technologies have been continually classified as longer term prospects in assessments carried out on behalf of the UK government, and even those closest to reaching market competitiveness, such as wind, require time to actually develop into profitable

industry, given the lead in time for projects and the long-term investment they represent.

It is too early to know what effects of the RO will have on technologies, however, it would seem likely that the RO will act to marginalise those technologies that are not yet market ready, by failing to provide any market at all for them. As the RO proceeds over its twenty-five year span, the obvious effect to which it will lead, would seem to be to act to reduce prices amongst those technologies which are already most competitive. This would suggest that the market-ready technologies will be advantaged over the less ready technologies, which are much less likely to receive contracts within the RO. Obviously, the RO is only applicable in the UK, thus the possibility remains that technologies continuing to develop outside the UK will be able to achieve price reductions that do make them competitive within the UK, and will thus be able to access the RO more effectively. Further to this, the scope of the RO, and the targets set by the UK Government, are significant enough that it is possible that some technologies may be drawn in, if the presently cheapest options are unable to fill the full obligation resting on the suppliers. Obviously, these will at least have to be within the cost range created by the existence of the buy-out price. In this sense the buy-out price may form a very real barrier to technologies in that those not able to meet this economic target may well be barred from funding that would enable them to meet it more easily at a future date.

#### 7.10 Policy Catalysts for Industrial Growth

The NFFO mechanism, operating as the only support mechanism for the development of renewable energy in the UK, and with its focus almost solely on increasing the installed capacity had no real application to encouraging the growth of UK industry, despite stated Government policy. The NFFO acted to deflect attention

from this area, and effectively masked the barriers to the development of an internationally competitive industry in the UK inherent to the UK NIS achieving such an end. The last contracts under the NFFO mechanism were awarded in 1998. The successor to the NFFO, the RO, is also supposed to address the potential for the development of new competitive industries for the UK. The potential for any new scheme to achieve such a goal will be severely restricted unless the policy components necessary to avoid these obstacles are also addressed. To do otherwise would effectively render the stated objective as merely a sugar coating to justify the pursuit of policies regarding the development of renewable energy based capacity to those who oppose them on a wholesale basis.

Essentially though, the policies that have been essential to developing a renewable energy manufacturing industry in each of Denmark, Germany and Spain have been those that can be turned to the greater advantage of domestic manufacturers. These include provision of grants, soft loans and a number of other mechanisms as described in the relevant chapters for each of these countries.

The UK has steadfastly refused not only to employ protectionist policies, but has largely eschewed mimicking the mechanisms themselves, even without giving them a protectionist bent.

One area of recent UK policy that may be of particular note is the government's establishment of the Carbon Trust. The Carbon Trust is "an independent, not for profit, company that will invest public and private finance in low-carbon technology" (Delay 2001). It is one of the measures introduced with the Climate Change Levy (CCL) and will receive a portion of the revenue raised by the CCL, presently projected at about £130 million. The aims of the Trust include a

range of programmes to promote low carbon research and development and help business invest in energy efficient, low carbon technologies and practices. Low carbon technologies are those which encourage energy saving measures, lower carbon fuels and renewable energy (Delay 2001). The Prime Minister at the time of the proposal of the Trust, Tony Blair, was quoted as saying that “the Carbon Trust will take the lead on low-carbon technology and innovation in this country, and put Britain in the lead internationally”.

To some extent the Carbon Trust would appear to display similarities to the German use of investment banks as part of the system of Public Sector Governance as described in detail in chapter five, though the final details of exactly how the Trust will operate are not yet in the public domain. There remain a significant number of important differences however. Fundamentally, the funding provided by the trust does not seem likely to be supplied as a form of support in line with a cohesive industrial policy as is the case with the German investment bank. The stated policy objectives of the Carbon Trust, as described by its Chief Executive (Delay 2001) are;

- Ensuring UK businesses and public sector contribute to meeting CO<sub>2</sub> targets.
- Improving UK competitiveness through resource efficiency.
- Developing a UK industrial sector supplying low carbon technologies nationally and internationally.

With regard to this research, the third of these is the most interesting. On the surface such a policy for a government initiated agency would suggest the possible creation of an aspect of industrial policy not dissimilar to the publicly funded investment banks which are key to the stimulation of new industry in Germany.

Introducing such a policy of in the UK would be something of a departure from previous UK policy regarding the stimulation of industry.

There are a number of notable differences which mark the UK set-up of the Carbon Trust in comparison with the German institutions however. In Germany the investment banks are essentially tools for directing finance towards the establishment of SME's, and funding is specifically channelled towards particular industries with the aim of establishing the dominance of German companies in that industry. In the UK, the Carbon Trust funding would appear to be unlikely to be specifically directed to supporting the establishment of new industrial sectors, but rather to support projects purely on the basis of the volume of carbon that the project would mitigate. A further significant difference which relates to this is that the UK Government does not appear to have the level of control over the funds that the German Government holds over the funds of the German investment banks. The UK Government effectively bowed to pressure from the Advisory Committee on Business and the Environment (ACBE) which suggested that industry itself should exhibit a strong degree of control over the destination of the funds which are effectively generated from industry through the CCL mechanism. The result of this greater dominance by industry in directing funding is, in the opinion of the author, likely to mean that funding is directed towards established business rather than specifically to the needs of new industry. The result being that funding will effectively not provide the same stimulus to new industry that is the case with the funding provided through programmes such as the European Recovery Programme run by the Deutsche AusgleichsBank. In this context, the Trust may prove to be less effective in terms of driving new environmental technologies and industries and thus in creating overall social and economic benefits than might have been the case with an alternatively

directed mechanism. It must be noted of course, that the operation of the Carbon Trust is still at an early stage and that the final performance of the mechanism can not yet be adequately judged.

#### 7.11 The Potential for Future Wind Turbine Manufacturing in the UK

With the end of the NFFO, the opportunity existed to install a mechanism more amenable to the growth of both the industry and of capacity. A mechanism which addressed the practical needs of industrial development might well be at odds with the strategy which has so far been dominant in the UK, and which tends to address deployment alone. The alternative is to have some separate mechanism from the main one which is directed specifically at the encouragement of the industry.

A number of different mechanisms have been outlined in various forums but these have tended to be aimed at the encouragement of deployment and have lacked any in-depth assessment of the problems of encouraging domestic industry. If the examples of Denmark, Germany and Spain are to be followed, the wisest course may be to have separate mechanisms put in place, aimed at encouraging industry, as adjuncts to the main mechanisms aim of encouraging increased use of renewable energy. These adjuncts could be targeted specifically at the encouragement of British industry in the field. There are a number of problems with this approach however. Firstly, and most importantly, policies specifically and transparently favouring domestic industry are likely to clash with both European Union competition law, and with World Trade Organisation (WTO) commitments. Whilst it is acceptable for financial advantages to be given in an effort to aid the encouragement of the growth of new markets in individual EU states, particularly in cases where the new market thus created will be environmentally beneficial, the obvious example being the financial support being given to renewables to reduce their costs in comparison to

other energy sources. However, EU legislation regards as anti-competitive any attempt to bias these policies in favour of the domestic industry of the state initiating the subsidy.

There is of course a certain degree of latitude involved in this process, that is, it is possible to act in such a way that an advantage is garnered without falling foul of the European Commission. An example perhaps being the well known Danish Bottles case, as described in chapter four. While that particular ruling kept the Danish market on an open and competitive basis in theory, several commentators have suggested that even the initial restriction, that all containers must be re-usable, grants an advantage to those Danish companies in their home market place, by causing imports to have to tailor their output specifically to the Danish market, thus increasing their operating costs, and reducing their competitiveness. It is possible that Danish regulations requiring the use of two braking systems on all turbines sold in Denmark is another example of this type of trade restriction.

In addition to gaining an advantage in such a way, it is possible to provide funding through open programmes in such a way that either they escape the attentions of the European Commission, or give the appearance of being fair. The legal process is also such that the Commission may take so long to investigate complaints that a domestic industry may already have been advantaged by the time action is taken to prevent the abuse of competition law.

Examples of such behaviour could include the initial BMFT subsidies provided to encourage the take-up of turbines in the early 1990's, two-thirds of which were spent on the purchase of German manufactured turbines, and as detailed in chapter five. The system presently in place in Germany, which provides 'soft' loans to purchase wind turbines, and which also seems to favour the purchase of turbines



manufactured in Germany may also be regarded as an example. The first of these measures came and went too rapidly to attract the attention of the European Commission, by the time the fraction of the funds it provided to German manufacturers had been calculated the subsidy scheme had finished. The second, as with the BMFT subsidy, goes to some purchases from non-German sources, but the majority would again seem to accrue to German companies simply based on the fact that most of the capacity installed in Germany at the present comes from German manufacturers, though little analysis of this has so far taken place. The openness of the application process may help the mechanism to avoid EC interference, and attention may also have been deflected by the Electricity Feed-in Law (EFL). The EFL has been the subject of some considerable contention and has attracted the notice of the Commission with regard to the unfair advantages it is now judged to give to renewable energy, in comparison with non-renewable sources, in Germany.

Similar schemes, or at least schemes with the same aims, could perhaps be instituted in the UK, though this would require a policy change such that this kind of financial support met with the approval of the UK Government. Obviously these would have to be introduced in such a fashion as to suggest that they were equally open within the EU whilst actually proffering an advantage to UK companies. Whilst political difficulties would exist, it is conceivable that these could be circumvented though the likelihood of this occurring in the UK is low. Given the almost non-existent state of the British turbine manufacturing industry at present, policy would have to be applied over an extended period if the example of Germany is to be repeated in the UK. Germany has experienced difficulty in breaking into the international turbine manufacturing industry despite a more suitable NIS and the commitment of billions of Deutsche Marks to such an end.

One path that might be worthy of consideration concerning UK manufacturing of turbines, is the possibility of the UK becoming a manufacturing centre for the production of turbines by companies from outside the UK. While this does not provide the full range of economic benefits that come from a domestically owned industry it may be considerably easier and cheaper to achieve, rather than attempting such an expansion. Becoming such a centre means attracting companies to the UK in preference to other countries. As with the establishment of a UK-owned industry though, achieving this would, in all likelihood, require a commitment on the part of the UK to dramatically increase its installed capacity of wind generated electricity. Committing to a large enough volume would enable the UK to achieve a position whereby it would be economically beneficial for non-UK companies to relocate production facilities to the UK. They would thus create manufacturing jobs directly relating to the volume of capacity committed to. Encouraging the siting of wind turbine manufacturing in the UK in this way also brings other advantages, the primary ones being the increased level of expertise it brings to the UK workforce, and the new support industries that it would be likely to lead to, also based in the UK. A report from Greenpeace (Greenpeace 1998) suggested that reaching the UK Government target of 10% of electricity generated from renewable energy sources by 2010 using wind energy would mean a total investment in the industry of £12 billion. This, in turn, would imply an estimated further investment in components equal to approximately 50% of this figure.

The Greenpeace document focused on the potential for the development of a UK industry to specifically exploit the market for offshore-sited wind farms. Offshore turbines have been put forward as the likely development of wind energy, particularly in the Europe, given their advantages in terms of avoidance of the need

for planning permission and the problems that go with it. The move offshore presents the opportunity to construct much bigger turbines without the controversy that generally accompanies them onshore. This increase in size may also offer the chance for the technology to become more cost effective through economies of scale. At present the costs of electricity generated from offshore sites is estimated as being roughly 30-40% more expensive than onshore sites. The actual amount will of course decrease in line with advances across turbine technology as a whole, and by a further increment as a result of the advances in the technology specific to offshore operation. In terms of a developer's full portfolio of projects, this cost differential may come down given the greater potential for approval offered by offshore development, and thus the reduced overall development costs.

The problem with the UK gaining access to the market for offshore technology are likely to be similar to those relating to onshore, in that both applications stem from offshore being a straightforward and direct continuation of the onshore technology. The only significant deviation are the turbine support structures and the connection technology. While this is a potentially valuable market, it is more a development of an old technology rather than a completely new one, thus the companies, and the countries, which have the advantage in the original market will be strongly advantaged, though the UK may gain some advantage from its greater experience with offshore technology utilised in the gas and oil industry. There may be some potential to gain early experience in the actual siting of turbines and the physical infrastructure that would need to accompany them. If the UK is to exploit any reasonable volume of its wind capacity, offshore is likely to comprise a significant fraction. By committing to offshore wind at an early stage in its development as an industry, alongside a commitment to increase capacity overall, it may be possible to

aim at attracting foreign investment with some ease. It may thus be possible to encourage the growth of British-owned companies to supply the support structures for offshore turbines. This would allow gains to be made while this aspect of the market is still in the early stages. The scale of the farms that have so far been proposed suggests that they will be of a scale to dwarf typical onshore wind farms in Europe. This is not to rule out the possibility that UK companies may still have the potential to enter the international wind turbine market. The simple example of Spain's late entrance to the industry serves to indicate that the sector is still accessible, and the following chapter will present further evidence that the market still offers opportunity.

The present situation however is such that the UK's competitors have begun to construct offshore wind farms. As of mid-1998 there were five operational offshore wind farms in the world, all of them in European waters. Two were off Denmark, two off the Netherlands and one in Sweden waters. Plans for at least twelve more farms had been drawn up, including three off the UK, two each off Sweden and the Netherlands, and most notably, five farms are planned for construction in Danish waters, these have respective capacities of 2350MW, 600MW, 600MW, 300MW and 15MW for a combined increase, if all are realised, of 3865MW. These plans would account for practically the whole of the 4000MW increase in offshore wind capacity that Denmark committed itself to in the Energy 21 document of 1996, though whether they are an accurate representation of the farms that will eventually be constructed remains to be seen. Contracts for 750 MW of offshore windfarm are currently on offer in Denmark, split into five farms of 150 MW each. A 40 MW farm is currently under construction on the Middelgrunden sandbank off Copenhagen.

This kind of long term policy enables Danish turbine manufacturing companies to operate in a more secure environment with regard to planning their

future development, as well as allowing other agents, notably financiers, to have greater assurance concerning the risks of getting involved in the industry. The Danish domestic industry is thus rendered more secure, more stable and better prepared to operate in the international marketplace.

In the UK, offshore wind installations have so far been limited. It was strongly rumoured that some projects might be included in the fifth round of the NFFO, this however was not to be the case. The renewables obligation preliminary consultation document, with its announcement making grants available for a limited number of offshore wind projects, plus a further announcement stemming from the 2001 budget statement, means that a limited number of grants should be available for stimulating the initial move to offshore wind in the UK. Greenpeace identified three possible projects in 1998, these were a 30MW farm at Gunfleet Bank, a 30MW installation at Scroby Sands and a 1.5MW farm, consisting of two 750kW turbines at Blyth. The development at Blyth, expanded to 4MW became the UK's first operational offshore farm in late 2000. The Blyth farm was able to be classed as an extension of the wind farm that was already sited on the Blyth harbour wall. As such it was able to receive payments within NFFO-4. It has also received a £700,000 grant within the European Union's Thermie scheme, underlining another of the advantages which it is possible to accrue by being among the first to investigate environmentally beneficial technologies.

As has been mentioned, the Government has committed over £200 million to provide grants to encourage the development of offshore wind projects.

The downside of a policy which relies on foreign investment – that is, one in which the UK does not have an established industry under British ownership – is that the UK does not then accrue the large scale benefits of expansion in the world market.

This is not to say that this direction is not a worthwhile one. It may be the only one available to the UK, other than to stay outside the manufacturing process entirely, and continue to import the vast majority of turbines for domestic use.

It is perhaps worth mentioning that the process of the UK being used as a manufacturing centre for foreign owned turbine companies has already begun to occur. The purchase of WEG and of Taywood Aerolaminates by one of the market leaders, NEG Micon, sees the Danish company take over an established company and gain the experienced workforce, a fully equipped manufacturing premises and the rights to the turbine designs owned by the purchased company. The announcement by Vestas in mid-2001 that they intend to establish manufacturing facilities in Scotland is a further indicator of such a movement.

One of the problems Walker identifies with regard to general British policy is that encouraging the growth of foreign direct investment in the UK has frequently resulted, not in a transfer of skills to the UK workforce, but instead has led to the UK acting merely as a manufacturing production line. It is a matter of circumspection as to whether this would be the case with respect to a non-UK owned wind turbine manufacturing presence in the UK. It is perhaps possible that the quality of craft skills needed in turbine and blade production will mean this phenomenon can be avoided however.

Linked to this is the issue of education. Traditionally the UK has had a very poor level of education and training in comparison with Germany, and other developed countries, particularly in the area of engineering (Prais 1988). While considerable effort has been expended in improving this situation, the UK remains behind its competitors, thus damaging its efforts at competing across the board as well as in the specific instance regarding a wind energy manufacturing.

Walker also presents convincing evidence regarding the UK's weaknesses in the areas of high technology, highlighting the fact that the UK's performance in a range of high-tech industries has declined markedly in comparison with its competitors and with past performance, with the exception of the defence industry.

#### 7.12 Discussion

It is possible that the UK has missed its opportunities to gain access to the wind turbine manufacturing field. There may be the potential to encourage industry to re-enter the sector, a move which will require the investment of large sums of money – though it should be noted that a considerable amount of money will have to be invested in purchasing renewably generated electricity in the near future anyway, not necessarily with any return on investment in terms of social gains. Such an investment would seem unlikely to occur within the present context of the UK NIS, and if provided would obviously not provide any guarantee of success. Though it should be borne in mind that the UK also has the potential for some gain as a manufacturing centre of excellence and the concomitant benefits this would bring. This is not to suggest that this is definitively the case. The following chapter will suggest that an opportunity to access the market for wind turbines may still be available.

What can perhaps be learned from the UK's failure to so-far capitalise on the potential of manufacturing wind energy related products, particularly in the light of the success of other nations in the sector, is to make more serious attempts to ensure early access to the markets for manufacture of other renewable energy generating technology. There are a number of lessons for other renewable energy technologies and the relevant industries to garner from the UK's failure and its competitors success with regard to the exploitation of wind energy technology. The following chapters

will discuss this relevance with regards to the future development of a photovoltaics industry in Germany and the UK.

The UK has now created what could be a huge market for wind providing that wind can be brought in economically, though problems with lack of planning permission still has the power to disrupt expansion.

If there is going to be any chance of a UK turbine manufacturing sector it is going to require organisations willing and capable of trying to establish them. This may require the direct intervention of the government in encouraging involvement. What is notable about wind energy in the UK is that a number of the major developers are connected to large scale utilities. These are willing to get involved in the development of turbine projects but so far have been more reticent about involvement in the manufacturing side. The introduction of the renewables obligation has the potential for the creation of a considerable domestic UK market for wind, though it is not as solidly confirmed as in those countries which initiated growth through the application of a REFIT mechanism, rather than an RPS mechanism. Such a domestic market is clearly essential to the development of a domestic industry as has been plainly demonstrated in Denmark, Germany and Spain. However, the creation of such a market does not imply the certain creation of a domestic industry. Those countries which have established such an industry have done so as a result of additional policies aimed specifically at their encouragement. These policies have not been identical in each case, but have been appropriate to both the mechanism for industrial development of the country in which they have been introduced, and to the particular circumstances of the overall industry at the time of their employ.

Further, they have been able to be introduced due to close work between industry and government as to what each of the other requires, in order that the aims



of each may be better accommodated. Such an approach has been lacking in the UK. Efforts in the UK have been characterised by poor co-ordination of policy amongst the different government departments who have responsibility for various aspects of RE policy. This is typified by the example of apparent Ministry of Defence (MoD) objections to DTI plans to expand offshore wind utilisation on the grounds that it would interfere with national defence, though there are numerous examples in recent history. The poor communication within government has been further exposed and matched by poor communication between government and industry, and all of these interactions, as well as those between these two bodies and academia need to be addressed and resolved if the UK is to effectively work towards developing new RET based manufacturing industries.

#### Main Points of Chapter Seven

- The UK Government has a standing policy commitment to aiding the development of competitive renewable energy technology manufacturing industries, which has been reiterated in every major policy document of the last decade.
- The UK has committed to ensuring complete openness and transparency in encouraging the growth of its renewable energy technology sector.
- There are no UK-owned manufacturers of commercially successful, large-scale wind turbines.
- The NFFO was not designed to support a UK renewable energy industry, and in practice acted to assist the growth of non-domestic industry.
- There are likely to be strong limitations on the policies available favouring the establishment of UK RET manufacturing industries, largely for political reasons. Regulatory rather than fiscal instruments may be more appropriate and acceptable.

## **Chapter Eight: The Contextual Development of the Wind Turbine Manufacturing Industry**

### **8.1 Introduction**

This chapter is primarily concerned with addressing the typological theory for entrepreneurial success proposed by Low and Abrahamson (Low and Abrahamson 1997) in the context of the wind turbine manufacturing industry, as first broached in chapter three. This theory is a relatively new one, furthermore it has not previously been applied to the wind turbine manufacturing industry. Chapter eight attempts to show that the evidence of the development of the wind turbine manufacturing industry, as presented in previous chapters, shows sufficient equivalence with this theory that it is possible to extrapolate something of the future direction of the industry. Further to this, the chapter presents evidence that opportunity still exists for new companies to access the wind turbine manufacturing sector. This forms a considerable aspect of the original work carried out with regard to this research.

### **8.2 The Historical Development of the Wind Turbine Industry and the Typological Theory of Low and Abrahamson**

Whilst the history of the turbine industry can be regarded as being a continuous process, for the purposes of this analysis it is broken down into three sections. The first is the development of the industry up to 1990. As has been described in earlier chapters, this is taken to be largely represented by Denmark, on the basis that this was the home of those companies which have enjoyed significant success, often enduring to the present. Morthorst applies a similar perspective in a 1998 paper, largely taking Danish industry to be representative of the industry as a whole, due to its dominant position (Morthorst 1998). This first section thus principally deals with events as recorded by Karnøe (Karnøe 1990).

The second section deals with the expansion of the industry beyond Denmark and the growing involvement of non-Danish companies.

The third section deals more specifically with the establishment of the Spanish marketplace, and the rise of Spanish industry. These latter sections apply the evidence from the four country case studies that make up chapters four to seven to demonstrate parallels between the reality of the development of the wind turbine manufacturing industry, and the typological theory expounded by Low and Abrahamson.

The manufacturing of wind energy technology can, unarguably, be regarded as the most successful of the industries to have so far emerged from the range of options for new and renewable energy sources that have been identified. As has been shown in previous chapters, the industry, its history and development, have received a significant degree of attention and have been chronicled in a number of forums, notably by both Karnøe (Karnøe 1990) and Gipe (Gipe 1995), though these analyses were in different contexts and slightly different conclusions were drawn.

In this discussion it is important to note that similar terms are used in Karnøe (Karnøe 1990) and in Low and Abrahamson (Low and Abrahamson 1997) but with different meanings. Karnøe uses the term ‘technology phase’ where Low and Abrahamson use the term ‘industrial phase’ to describe the state of the industrial sector in terms of its stage of growth. Karnøe also uses the term ‘industry phase’ to refer to a more detailed breakdown of Danish industry in terms of changes within the industry with regard to operational development and growth. Karnøe describes Danish wind technology as having experienced four industrial phases, and as having entered a fifth by 1988. He describes the industrial organisation at that time as being in a phase of consolidation – equivalent to what Low and Abrahamson call the growth

phase – which is dated as roughly beginning in 1984 and which superseded the emergent stages of the industry. Karnøe also predicts that at some future date the industry will move from this consolidating phase to a third, or mature, phase as all industries tend to. Andersen and Jensen (Andersen and Jensen 1997) predict that such a move will be effectively completed by 2030, though they do not attempt to predict precisely how and when this change will occur, favouring instead a likely representation of the industry as it will then operate.

More generally, Low and Abrahamson (Low and Abrahamson 1997) use the same breakdown of industry into three phases of industrial organisation, which can be regarded as a standard representation of industrial development. It should be noted that Low and Abrahamson label the phases as emerging, growth and mature. These phases are defined as corresponding to the creation, exploitation and erosion of competitive advantage within every industry, and develop out of various theories that have been proposed, suggesting, in essence, that the “strengths of large, old organizations are often the weaknesses of small, new organizations and vice versa” (Aldrich and Auster 1986; Low and MacMillan 1988). Low and Abrahamson define industries as firms of the same organisational structure, and suggest that this means they are able to circumvent the problem of the shifting of industry boundaries, and to differentiate between innovative and stabilising entrepreneurial activities in an industry.

Low and Abrahamson (Low and Abrahamson 1997) offer a simple definition of entrepreneurship as being the creation of new organisations and state that this creation can be viewed as a context-dependent social process. They make the simple assertion that new organisations are created as ‘critical stakeholders change their behavior in ways that allow the organization to emerge’. Success for an entrepreneur

is defined as a new organisation achieving a state whereby it is no longer in short-term danger. A typological theory of success is then developed through examining the fit between social context and four critical dimensions, namely entrepreneurial networks, entrepreneurial confidence building behaviours, motivation of stakeholders, and finally, organisational structures and strategies. Low and Abrahamson suggest successful market access is impossible if any of these factors does not fit with the others, and within the social context. They also suggest the better the fit, the greater the chances of success. One implication of this is that there must be something of a range for the sum of the attributes that a company can possess and still be successful, and still be demonstrating the characteristics for each dimension which are necessary for success. Companies do not have to be identical to succeed, but they are likely to share a number of characteristics.

Obviously, there is considerable room for variation in each of the four dimensions identified by Low and Abrahamson. Entrepreneurial networks may vary in terms of the existence of weak or strong ties and in terms of the existence of networks either homogeneically or as unrelated subgroups. Confidence building behaviours are classified as either formal (e.g. contracts) or informal (e.g. personal interaction), and companies can exhibit characteristics relating to both of these. Stakeholder motivations can be analysed as stemming from social or economic reasons, and again a mix of the two is likely to be apparent. Structure and strategy are discussed in terms of the existence of market or hierarchy orientations and the degree of innovation or imitation existing.

Low and Abrahamson conclude that there are only three possible bases from which firms can enjoy entrepreneurial success and that these are the products of the three phases of industrial organisation which they define; emergent, growth and

mature. They label the successful configurations relevant to the context of each phase as, respectively, **movements**, **bandwagons** and **clones**. Low and Abrahamson provide definitions of each of these. What is more important in terms of this research, it is suggested, is that the general model they propose can be shown to match the wind turbine industry quite distinctly.

The Low and Abrahamson description of those firms which enjoy entrepreneurial success during the emergent state of an industry, labelled **movements**, are characterised as pioneers which exist as part of unique networks which enable them to seize on opportunities to bring together different concepts to realise new combinations. Typically, movements have strong ties to two or more non-overlapping networks and the entrepreneur is supported by driven shareholders whose primary motivation is social rather than economic. The credibility of the entrepreneur is achieved through informal means, for example, personal interaction and word of mouth. The organisational structure of such pioneers is typically market based, and participants commit within the context of 'flexible, co-operative agreements'. Business strategy is based on innovation and experimentation, and a belief in the validity of the new organisational structure.

With the early Danish industry responsible for such a considerable portion of the entrepreneurial success of the emergent stage of the industry, and of the early consolidation/growth stage in the form of companies such as Bonus, Vestas and Nordtank this model would seem to be an appropriate one up to at least the stages covered in some depth by Karnøe.

Comparing the definitions made by Low and Abrahamson, with the history of the Danish turbine manufacturing industry as described in Chapter Four, it can be demonstrated that the industry provides an almost definitive demonstration of Low

and Abrahamson's general model (Jamison, Eyerman et al. 1990; Karnøe 1990; Madsen 1990; Maribo Pedersen 1990; Øster and Jacobsen 1990; Gipe 1995; Krohn 2000).

### 8.3 The Emergent Phase of the Wind Turbine Industry

The emergent phase of the industry displays characteristics very much in line with those predicted by the Low and Abrahamson model. The companies which formed tended to do so as the result of the actions of a socially motivated grass-roots movement, which effectively ensured that these were the primary stakeholders in both the new market, and in the new businesses, they were effectively creating.

The network characteristics of the companies formed in the creation of the turbine industry were also defined by their origin, that is to say, they were result of the conjunction of two other networks, engineers with the technical capabilities to design and implement the use of a new technology, with environmentalists looking for alternatives to nuclear and fossil fuel.

The structure of these companies was forced by the limited facilities available in to producing only a limited number of turbine components. The most telling example of this being reflected in the effective stagnancy of the market until generically useful blades were made available (Madsen 1990). Effectively the structures of the early Danish companies were horizontal by default.

The strategies of new companies at this stage, were, by dint of the largely undeveloped state of the technology, forced to be innovative in order to have an available product, and to be able to keep competing in a limited market place. This can be tied in to the confidence building mechanisms that were the basis of successful operation in the early stages of the turbine industry. Confidence in turbines at this stage was largely built on word-of-mouth and the ratings they received in *Naturlig*

Energi, the journal of the Association of Danish Wind Power Owners (Danske Vindkraftværker – DV). Both of these are informal mechanisms, and thus match those that would be expected of successful companies in the emergent phase, as described by Low and Abrahamson.

The success of the early companies was to be supplanted by the advent of companies like Vestas, NEG-Micon and Bonus. After displacing the very early companies which had served the Danish market, they were then also able to survive the change to the consolidation phase – indeed their advent would seem to herald the move to the consolidating phase, as Karnøe terms it. These companies embodied the differing range of qualities which were needed both to survive in the burgeoning Californian market of the mid-1980's, and to lay the foundations for survival beyond it.

Low and Abrahamson's definition for **bandwagons**, that is, the type of firm capable of successfully joining an industry during the growth phase, details a number of characteristics necessary for the success of entrants which are very different from those required for successful entry to an industry at the emergence phase. Notably, these shifts require that the entrepreneur now needs to have access to a more extensive network which should consist of high status individuals who can be tapped quickly in order to exploit opportunities rapidly. Stakeholders are likely to have economic factors as their primary motivation. Methods for increasing consumer and investor confidence exhibit a significant change, becoming more largely based in increasingly formal instruments such as performance guarantees and contracts. The strategy of successful companies within the industry, it is predicted, remains entrepreneurial and innovative but tempered with a greater tendency towards awareness – and imitation – of rivals.



These defining characteristics of the growth stage would also appear to tie in with the development of the wind turbine manufacturing industry in so far as the stage to which Karnøe is able to describe it, and beyond this to the present stage as described in chapter four.

Examining the turbine industry in terms of the key characteristics shows that during the period which Karnøe notes as signalling the change from the emergent phase there are a number of indicators that match the generalised model.

In terms of the network characteristics, the period identified by Karnøe as the consolidating phase was one which saw a definite move away from the situation wherein turbine manufacturers held strong links to only two sectors, notably to environmentalists and to certain limited areas of engineering (Madsen 1990; Maribo Pedersen 1990). In order to survive, Danish companies had to expand their networks to be able to operate in the new international markets, at this time primarily California. This required interaction with a greater range of other actors, the kind of changes necessary being exemplified in a simple form by Karnøe's observation of a 'service manager used to handling small daily problems suddenly finding himself calling a Jumbo-jet to the nearest airport' (Karnøe 1990).

Servicing the Californian market also drove changes in the methods turbine manufacturers used for confidence building. A switch occurred from the initial turbine market which had seen consumer trust based on personal experience of particular turbines and on word-of-mouth within a small community, to a system relying on more formal, financially based guarantees.

At the same time there was a clear shift in the motivations of shareholders in new companies entering the turbine manufacturing industry. Socially motivated actors, such as Riisager, and their investors, as described by Gipe and by Jamison *et*

*al*, gave way to more economically motivated companies such as Vestas and Bonus, whose motivation was in finding alternatives to the diminishing agricultural engineering sector (Jamison, Eyerman et al. 1990; Gipe 1995).

The final characteristic dimension – organisational structure and strategy – as defined by Low and Abrahamson predicts a continuous shift from innovation to imitation of technology in order to minimise risks as the industry moves from emergence to growth to maturity. This continuous path makes it difficult to judge change in comparison with some of the other, more indicative, dimensions. It is possible however, to regard the movement along a path of increased industrialisation during the 1980's, as observed by Karnøe, and the increased formalisation of knowledge that came about as a result, as well as the movement caused toward a greater degree of science-led research – and consummate comparative reduction in learning-through-using – as indicating a move along the path away from the more purely innovative basis of the early actors within the industry. To give a specific example, Enercon's entry to the marketplace was based, along with other German turbine manufacturers on success in imitating the basic design of Danish turbines, only once the company was established was it able to innovate with pitch regulation and gearless operation of its direct-drive machines (De Vries 2001). Essentially, Enercon is a primary example of a successful bandwagon entrepreneur, combining a mixture of imitative and innovative strategies appropriate to competing in the growth phase.

Low and Abrahamson's linking of entrepreneurial success to the degree of fit of enterprising firms with the prevailing nature of the organisation of the industry naturally has very significant implications for new companies. It also seems likely to

have implications for those companies already established, but facing changes to the industrial phase in which they have become established.

The fit of Low and Abrahamson's general model to the specific history and circumstances of the wind turbine manufacturing industry may allow us to assess the potential for new entrants to succeed with regard to the particular circumstances which might be prevailing at any point.

The wind turbine manufacturing industry has continued to develop and grow since Karnøe first assessed it as being in a consolidating phase in 1990. Whether it remains in this phase, has moved on to a mature phase or whether it is close to changing between these phases is a central aspect of this research, in so much as it is fundamentally related to the potential for success of new entrants to the industry and to the continuing success of established actors.

There have been a range of stages, and thus changes, since Karnøe's 1990 assessment. These include the creation and attempted accessing of the market by a number of new companies, successfully or otherwise, as well as the greater internationalisation of both the marketplace, and of the companies acting to exploit it. Most of the major companies have expanded the range of countries in which they maintain offices. The period has also seen the acquisition of the smaller German company, Tacke, by the American company Enron, which is itself experiencing considerable success in capturing a number of major US based contracts. The converse of this of course has been the failure of a number of entrepreneurial efforts.

While the recent rounds of consolidation would suggest that the organisation of the industry has yet to reach the mature phase, at least within the context of Karnøe's definitions, it might be worthwhile to examine recent entrants to the industry. The major entrants into the marketplace since the 1990 Karnøe article

include a number of German companies, most notable for its success being Enercon, but also Tacke and a host of smaller companies. More recently a number of Spanish manufacturers have appeared and grown rapidly into serious concerns, and the American manufacturer, Enron, has continued to grow as the only major non-European manufacturer, even purchasing the German-based Tacke as mentioned above.

Consolidation has also continued to occur. Addressing the most recent period, the years 1996-1999 have seen considerably increased activity in terms of installed capacity, as well as demonstrating increased internationalisation of the industry. The Danish company, NEG Micon has arguably been the most active, though this has not come without a price. It was the world's largest turbine manufacturer in 1997 (FDV 1999) and followed an aggressive policy of acquisition and expansion, including purchases in the UK and the Netherlands, as well as in its native Denmark. This enabled it to expand both its manufacturing base, its knowledge base and the technology to which it has access. The period has also saw the company pursue a number of joint operations in countries such as India, and it has recently declared its intention to establish manufacturing plants in Canada and the USA. Vestas, its largest competitor has initiated joint ventures in Spain, Italy and India. The biggest of the German manufacturers, Enercon, has established manufacturing in India and Brazil in addition to constructing new facilities in the East of Germany. One of the key aspects of this chapter is to analyse the industry for characteristics of mature phase industrial organisation and to assess the level of or lack of success that they have enjoyed. It must be noted that failure is not necessarily contingent on embodying the wrong characteristics but can be the product of a very large range of factors, including bad luck, as has been discussed in a variety of fora. Within the context of Low and

Abrahamson's definitions, the area which may be of greatest interest in the context of industrial organisation may be the success of the Spanish manufacturing companies.

Low and Abrahamson characterise successful entrepreneurial entrants to an industry in the mature phase, labelled **clones**, as exhibiting something of a reverse with respect to some of the key dimensions when comparing the changes from the emergent to the growth phase with the change from the growth phase to the mature phase, whilst noting a that there is a continual shift along a trend for other dimensions in the same comparison. It may be possible to more easily identify a change in the industrial phase through identifying this change in direction, through analysis of such reverses in the qualities of successful companies entering an industry, it is suggested here

Low and Abrahamson suggest that shareholders exhibit something of a shift back towards social motivations, striking more of a balance with economic motivations in comparison with those factors motivating successful companies entering an industry during the growth phase, so that shareholders are motivated by a mixture of the two groups of factors. Network size is reduced in comparison with the growth phase, successful entrepreneurs entering an industry at this stage typically having 'extensive and strong relationships, but primarily with individuals within their own industry' (Low and Abrahamson 1997), thus providing the entrepreneur with the capability to replicate the 'well-established organizational form' (Low and Abrahamson 1997).

Low and Abrahamson also suggest that successful entrants at this phase are also typically able to more easily include a greater degree of informal confidence building mechanisms, as a result of the increased familiarity of actors with formal mechanisms and the greater availability of these at more cost-effective levels. Low

and Abrahamson suggest this mix of informal and formal mechanisms is essential to success due to the linking of informal structures within the dense networks of this phase.

With regard to strategy, successful entry and – it seems likely – successful survival for companies already involved, will demand the achievement of ever increasing efficiency as the industry during this phase will largely be based on capturing ever reducing margins, leading to an increasingly hierarchical structure as companies examine the value chain for increased opportunity to internalise costs and increase competitiveness.

Mature phase entrants continue the trend towards a reduced level of innovation and experimentation as significantly greater opportunity exists for imitation of the competition, and, more importantly, as the reduced margins intrinsic to the nature of the phase can raise the dangers inherent in costly investment.

#### 8.4 Application of Low and Abrahamson's Typological Theory to the Wind Industry

As described in chapter six, the advent of the Spanish based turbine manufacturers is recent, even in the context of what is essentially a relatively new industry. Furthermore, employing the definition offered by Low and Abrahamson for the criteria indicative of success, a number of the Spanish manufacturers would appear to be successful entrepreneurs in the sense that they are no longer endangered in the short term. Gamesa, MADE, Ecotènia and Desarrollos have all seized significant sections of their domestic market, which is expanding rapidly and is on its way to becoming one of the most extensive in Europe. As a result of this, each has registered a position amongst the eleven biggest turbine manufacturers in the world. The Spanish situation is such that the domestic market is buoyant and at least three have secured contracts such that it would appear that they are secure in at least the

short term, thus they can be regarded as being successful within the definition provided by Low and Abrahamson, and apposite for the purposes of this analysis.

The four companies actually have disparate origins. The largest, Gamesa, is owned by a large and diverse Spanish power and banking conglomerate, Iberdrola and by the major Danish turbine manufacturer, Vestas. Gamesa has thus benefited from both familiarity with local business conditions, and of having access to proven technology. Consequently, it does not have to develop its own technology, and thus can avoid significant investment and risk. As a further consequence, Gamesa has access to a developed operating network, and the involvement of previously successful Spanish interests acts to increase confidence in the company.

MADE are a wholly owned subsidiary of the Spanish utility, Endesa, which, unusually in the European context, became involved in turbine manufacture and product development for itself.

Desarrollos are a subsidiary of another Spanish conglomerate, Abengoa, though their success in the initial years of the Spanish boom seems to have tailed off somewhat latterly.

Due to their ownership all of these companies have benefited in the Spanish market to which they have so been largely restricted, through availability of capital, and through taking advantage of already existing networks.

Each will be examined individually to ascertain the context in which they have managed to secure their short-term safety.

Gamesa will clearly be advantaged in terms of confidence building by the presence of both a major national power company, Iberdrola and a Spanish bank, BBV, and a major, internationally proven, manufacturer in the form of Vestas. The issue however, is what is driving this confidence. Clearly, the formal mechanisms

that have become the norm in the industry will be apparent, though this would be true of any successful company in either a growth or mature stage industry. What is relevant is the presence or absence of more informal mechanisms alongside the formal ones.

The importance of assessing the phase of industrial organisation is obvious, only entrepreneurs with the correct form of organisation will fit with the evolving context of the industry and enjoy success. Low and Abrahamson's theory emphasises the importance of identifying the changes in the organisational phase and allows these to be identified. It is implicit to their work that it is not necessarily possible for new companies to enjoy success in a field by emulating the operating paradigms that led to previous successes. If the context has changed it would be more useful for these new companies to emulate only those successful companies operating in the new context if they have begun in that context. They may also garner lessons from older companies if these have changed to take into account the demands of the new context.

With application to wind energy technology and its manufacture, the model has a number of implications for potential new entrants to the market, these being dependent on whether industrial organisation remains at the growth phase or has moved over the cusp into maturity. The existence of such a cusp would also have implications for all current operators within the industry. By analysing any changes that take place in respect of the dimensions identified by Low and Abrahamson and by recognising the direction in which change is occurring in respect of the dimensions it should be possible to identify the likely occurrence of such a cusp.

If the industry remains in the growth stage, effectively this forms a kind of status quo. The four dimensions identified by Low and Abrahamson remain relatively



stable, as does the context in which these dimensions must fit if success is to be enjoyed, though it is likely that the longer the period of continuity the more established existing companies will become and the more difficult it becomes for new companies to challenge their dominance. Potentially, new entrants to the industry could hope to enjoy success in entering a particular phase by emulating the start-up pattern of those who also entered in that phase, and by doing so more efficiently in the context of the proposed theory. These could be regarded as enjoying a closer fit to the ideal characteristics. With regard to wind turbine technology manufacturing this would include practically all companies presently operating successfully. It should be made clear that the suggestion of emulation in this case is not a suggestion regarding outright copying of technology, it applies to emulating set-up with regards to the four dimensions identified by Low and Abrahamson. Thus, while copying of technology is a natural aspect of overall imitation of industrial strategy, this might be balanced with application of imitative behaviour in innovation and strategy, and networking and stakeholder motivation must also fit the pattern.

Identification of the cusp between two phases of industrial organisation is a difficult procedure. While analysing an industry in terms of the four Low and Abrahamson dimensions with regard to the fifth dimension of context should provide indicators, some are more transparently indicative than others, and can be more easily recognised of being symptomatic of a shift.

With regard to strategy for example, the role of innovation declines from the emergent to the growth phase and then continues downward through the mature phase, it forms a continuum and no change of direction occurs to indicate a adjustment in context, it is only possible to identify new companies as being indicative of a new industrial phase through blunt comparison, and potentially this

could be affected by other factors. The other aspect of strategy and structure regarding the operation of companies, is the extent to which they rely on using either markets or hierarchies to achieve their goals. Again the movement from emergent to mature is a continuous one, making a shift from the market approach to hierarchical one. Thus neither are particularly good indicators of the phase of an industry.

The extent and degree of networking may provide some clues to a change; the difference between companies that might be regarded as successful movements and those that can be regarded as successful bandwagons with respect to this dimension is a significant one. The difference between successful bandwagons and successful clones may not be as obvious, the shift from weak to strong ties may again make it difficult to pinpoint a change. Though in theory the strongly tied network of the mature phase should be apparent, it would seem likely that this might be masked by weaker links, which while they fall outside the Low and Abrahamson definition of the mature phase, could realistically still remain apparent to the observer.

Thus a more sensitive, or at least, more apparent indicator of a shift in the phase may be activity in both the mechanisms employed for confidence building with regard to stakeholders, and to interactions within the industry. Both of these dimensions see a change in direction. In the shift of industrial organisation in the Low and Abrahamson model from growth to mature phase, both see a change of direction of the trend made in changing from the emergent to the growth phase.

Stakeholder motivation shifts from an origin based on social factors to economic factors in the phase change from emergent to growth, and moves back the other way to some degree in the shift from the growth to the mature phase. The mature phase is thus typically characterised by a mix of economic and socially motivated stakeholders. Similarly, the confidence building mechanisms which swung

from informal to formal in moving from the emergent to growth phase shift back towards a mixture of both. Thus, these two dimensions may be clearer indicators of occurring change.

Finally, the basis of Low and Abrahamson is the discussion of these four dimensions within the fifth dimension of the existing industrial context, and consideration of this may also be useful as an indicator. Low and Abrahamson note that the key challenges facing entrepreneurs also change with changes in industrial organisation, and as a factor of the context, examination may provide some clues to phase change.

In the case of movements, the key challenge identified is that of establishing the legitimacy of the enterprise at the industrial level - and individual firms also have to establish their legitimacy within that industry. Again, this would clearly tie in with the early history of wind turbine manufacturing and the struggle of the early manufacturers to establish their products as a worthwhile investment.

The key challenge for bandwagons is identified as that of prospering in a period of 'rapid growth and change' (Low and Abrahamson 1997). The entrepreneur entering the market at this stage is basically trying to do so as rapidly as possible while the opportunity is still available.

The key challenge for 'clones', is identified as surviving the competition at a point where finding a source of competitive advantage is a difficult task. Whilst this also applies to previously established companies, these may well have accrued a number of advantages by dint of their age, or at the very least, they avoid the liabilities of newness such as those identified by Aldrich and Auster, and which these authors associate with much greater rates of dissolution (Aldrich and Auster 1986).

One interesting aspect of the change between industrial phases which does not seem to have been covered in the literature is identifying the nature of the catalyst for change. For example, is the change led by changes in the demand of the supply side of the industry, by a combination of both, or by a continuous process of interaction between the two sides. The changes in direction of some of the dimensions identified by Low and Abrahamson would tend to suggest that the last of these is unlikely. The entry of some of the Danish companies which were to go on to dominate the industry are regarded to have entered the market at the latter stages of the emergent phase as identified by Karnøe, though the evidence would seem to be clear that they had the characteristics of growth phase companies from the beginning. Thus, this might be cause to suggest, at least tentatively, that the coming of new companies to the industry, and with a more effective operating paradigm are the forebears of the phase change to come. This is clearly something that would need to be tested in a greater range of industries and with a greater depth of analysis, before a firmer conclusion may be drawn.

Identification and awareness of the change, and whether it is likely to occur, is occurring, or has already occurred, has extremely important implications for entrepreneurs considering entry to the industry, as well as for existing companies. Clearly, adapting a new firm to achieve a fit with the particular context within the context of Low and Abrahamson's generalised model may be essential to continued survival.

It is established that the chances for survival of newcomers varies at different phases. Low and Abrahamson point out that both the number of entrants to an industry and the chances of success increase during the growth phase as the industry as a whole acquires an increased legitimacy. It seems likely also, that the new

entrants will have a greater struggle to enter a phase, the later they try to enter it, on the basis that the later the attempt to access the industry, the greater the chances that opportunities for seizing competitive advantage will have already been exploited by those preceding them into that industry. Low and Abrahamson also point out that it is established that there are certain points in the development of an industry when increased socio-political legitimacy increases, leading to a reduction in the failure rate of foundings. This leads to an increase in the number of foundings, and thus an increased level of competition. They also point out that the consensus within the field tends towards the belief that legitimacy of an industry is likely to be a continuous rather than step-function, but that the continuum is likely to be particularly steep at a particular point in each industries evolution. It may be of interest to consider whether such a gradation has so far taken place in the wind turbine manufacturing industry, or whether it can be expected to occur soon, though this research will not attempt such an assessment.

The opportunism of the growth phase may mean that late entrants at this stage may experience difficulties in combating the already established companies, indeed late entrants to any phase seem likely to be disadvantaged in comparison to companies which have had the opportunity to become established in that phase. Low and Abrahamson also suggest however, that it is possible that when a switch between phases occurs, it may be difficult for those companies which have started in the previous phase to change rapidly enough to compete with new entrants set up specifically with regard to the new context in which they are now operating. Thus, organisations founded as bandwagons may struggle to compete with clones once the context – that is, the form of industrial organisation – has changed to favour the clones. This would be similar to the situation in which firms founded as bandwagons

may be advantaged over those founded as movements, after the industry moves into the growth phase from the emergent phase. While Low and Abrahamson suggest that this area would require greater study before a more definitive opinion can be formed, their suggestion fits the circumstances of the modern wind turbine manufacturing industry's move from the emergent to the growth phase closely. If this pattern were to continue it would naturally be of concern not only to new entrepreneurs considering the industry, but also to those firms already operating successfully in the growth phase.

#### 8.5 Implications of Low and Abrahamson's Typological Theory for the Wind Turbine Manufacturing Industry

With regard to the wind industry, a number of commentators have suggested that the turbine manufacturing industry may be a difficult one to enter given the present pre-eminence, of and domination by, Danish, German and other companies. It has been suggested that the best way for countries such as the UK, which presently have little indigenously owned manufacturing capacity, to exploit the potential for new jobs and other economic benefits associated with manufacturing is to make a commitment to encourage the establishment of manufacturing facilities in the UK by non-UK companies. If the theory of Low and Abrahamson is correct however – and the strong fit of their model with the historical data presented in the four country case studies suggests that it is – then there may be a potential window in which new companies might be able to more easily access the market, and in which the presently successful operators may be more vulnerable. That is, it may be easier to access the market at the point at which the industrial phase changes.

Identification of the advent of this opportunity is obviously essential. Entering the market too early, before the context has changed, leaves the new firm to battle

against companies well suited to the prevailing conditions. Conversely, the longer it takes potential new companies to recognise and respond to the change in context, the greater the chance for other new actors to enter and establish themselves, and for previously successful companies to adapt to the new context, thus rendering competition more difficult.

Identification of the changing context is thus also of supreme importance to those companies which are already enjoying success in the growth phase, in order that they can make the necessary adaptations.

In terms of wind turbine manufacturing, it is interesting to examine the operating behaviours of the more recent entrants to the industry. If these are successful within the terms of the definition used by Low and Abrahamson, then these are the most representative of the prevailing industrial model within the typological theory. They are thus the most useful for this study.

There have been a number of new entrants to the industry in recent years. Some of these have displayed the characteristics that Low and Abrahamson use to define success. The new entrants to the Spanish market, for example, seem to match the definition. Whilst other companies are trying to access the industry, but lack of information about the operating procedures of these actors, the reliability of their equipment, and their potential for effective competition means that these are effectively ruled out of being useful for analysis as recent entrants to the industry. An example of a company falling in to this category are the ABB-backed Swedish company, Scanwind (De Vries 2001).

The new Spanish companies MADE and Desarrollos already appear to be displaying some aspects which suggest that they are clones of other operators and their success so far may be one indicator that a change has taken place. The pedigree

of the most successful of the Spanish based companies also provides an interest. While its access to Vestas turbine technology supplied by the Danish company who control a large fraction of its shares makes it difficult to analyse some aspects of its operation, it effectively doesn't need to have any policy regarding innovation. For example, it may be possible that such an operation is actually the response of one of the companies which emerged and operated successfully at the growth phase to changing circumstance. It is also possible to regard this incident and the other examples of this behaviour, such as the joint operations that have been established between Danish or German companies and domestic companies in India and China, as merely the natural expansion of these companies. This does not deny the possibility that they might also have a defensive effect. Clearly, it is in the interests of those already established in the industry to make any changes in their operations which would make them more capable of surviving in the new paradigm. What changes may be necessary are a matter for further research.

Of more interest here are the purely Spanish backed concerns of MADE, Ecotècnia and Desarrollos which do not have the links of Gamesa, but have established themselves and may present examples of successful clones.

The international nature of the industry, including the involvement of so many non-Spanish companies in the Spanish market would suggest that the situation in Spain is such that it may be indicative, at least to some extent, of the immediate direction of the industry. This does not imply that the industry moves as a whole however. It is possible that it may move at different rates in different countries, most notably, being slower in countries where an established industry already exists. If the industry has moved, or is moving, to the mature phase in Spain though, then it seems likely to be an indicator that the same circumstances may be beginning to apply to the



industry elsewhere. The new conditions may also apply in any new regions where an industry may begin to be established, for example, the UK.

Whilst a marketplace may be extremely unlikely to occur in countries like the UK without the introduction of some policies to stimulate its growth, any change in the industrial phase may provide new entrepreneurs and firms with an additional advantage if they are better organised to deal with the new reality of the changed phase. They thus might have a greater chance of successfully capturing any opportunity created through new policy than would be the case without the phase change. In these circumstances the new companies best positioned to take advantage are likely to be those for which the new market will serve as a domestic base, as has been the case in Spain.

#### Main Points of Chapter Eight

- Low and Abrahamson (Low and Abrahamson 1997) propose a typological theory which discusses the role of context with regard to the likelihood of entrepreneurial success for new entrants to an industry.
- Low and Abrahamson's theory closely corresponds with the description of the wind turbine industry up to 1990, as described by Karnøe, and beyond this date as described in the case studies presented in this research.
- The inevitable change from the growth phase to the mature phase seems likely to offer opportunities for new entrants to successfully compete in the wind turbine manufacturing industry.
- There are a range of indicators in the case studies that the change to a mature phase may be apparent.

## **Chapter Nine: The Potential for the Development of a UK Wind Turbine Manufacturing Industry**

### **9.1 Introduction**

This chapter will attempt to draw together any common factors highlighted by the four country case studies in chapters four to seven, and to use them to inform a commentary on the efforts of the UK in the wind turbine manufacturing industry in the past, and into the future. It will discuss whether it is still possible for the UK to enter the wind turbine manufacturing industry, and if so, possible strategies for how it might go about making such an entry.

This chapter, along with chapter ten, and to some extent, chapter eight, embodies the central conclusions stemming from this research.

### **9.2 Entry into the Industry**

In general terms, it is suggested that it is still possible to enter the turbine manufacturing industry. This is evidenced by the success of recent entrants. Chapter seven demonstrates the relatively late arrival of Spain into the industry, notes the level of success it has enjoyed domestically, and the subsequent expansion into the international marketplace which is likely to be essential to its continued growth and expansion as part of the world industry.

The next few years are likely to see a number of new companies attempt to access the wind turbine market. There are two potential newcomers whose announcements that they intend to enter the market have been of particular note. The first, is a New Zealand company, Vortec, attempting to promote the use of their cowled wind turbines, effectively a standard, large turbine fitted with a cowl to capture wind from a greater area and drive it through the blade sweep area, in order to maximise the output from the turbine. After announcing their intention to enter the

market from 1996, the company announced its closure in 2001 after zero sales, and with the loss of considerable investment capital. The second company is the Norwegian-based Scanwind, at the time of writing, testing the use of new equipment provided by the Swiss-Swedish conglomerate ABB and as yet commercially unproven. Should Scanwind prove successful, it would provide more evidence that the market is still accessible to new entrants, and thus its fortunes remain of interest. Notably, neither of these companies have their origins in those countries which are regarded as the champions of the technology, and of the industries that derive from that technology. Also notably, neither existed in an established domestic market, Norway had only 13MW of installed wind capacity at the end of 2000, whilst New Zealand had 37 MW (WPM 2001). This factor may have had some impact on Vortec's failure in that it may have affected perceptions of the scope for the use of the technology and of the potential for returns on investment. If, and how, this factor impacts on Scanwind remains to be seen.

The theory discussed in chapter eight goes beyond the simple interpretation of the Spanish case, and the simple implications that can be drawn from the successful entry of Spanish companies into the marketplace. By demonstrating a fit between the model and the behaviour of the most recent successful applicants, chapter eight conjectured that an opportunity beyond that inherent in the simple interpretation of the Spanish industrial case. Alongside the simple interpretation, this has the potential to act as a foundation from which to hypothesise on the possibilities for the establishment of a wind turbine manufacturing industry in the UK. The next stage is to assess what policies might be introduced in the UK which would encourage industrial growth as well as stimulate a market.

Fundamentally though, it must be borne in mind that the UK is not the same as Spain or any other country. There are fundamental differences in the National Innovation Systems, and thus policies that have proved successful in Spain, or elsewhere, may not be successful in the UK, and may not even be capable of application, for a range of social and cultural reasons.

### 9.3 The Application of Policy in the UK

When considering how policies that have proved successful in encouraging the development and growth of renewable energy technology (RET) manufacturing industries in other countries might be applied in the UK, it is important to first consider the political nature of the UK.

As has been discussed in chapter seven, the UK is, according to the OECD (OECD 2000), the nation with the least restrictive volume of trade regulation in the world. It seems unlikely that this regulatory regime will change radically in the near future, and thus any efforts to open new markets and encourage new industries must be in this context. UK policy also has to account for regulation evolving at the EU level. In the next decade this may mean the introduction of an EU wide directive relating to renewable energy.

A key step in developing an industry is the creation of a domestic market, and they may already have been addressed by the UK Government. The setting-up of the Renewables Obligation (RO) to replace the fading novelty of the NFFO displays a commitment to the legislated creation of a marketplace. The Renewable Portfolio Standard (RPS) style mechanism of the RO is a proven instrument for driving up capacity, as demonstrated through increases in wind energy capacity in a number of US states (Berry and Jaccard 2001; Espey 2001). It has yet

however, to be a proven driver of capacity in a country with a strong industry. The adoption of the RPS as the mechanism of choice in Denmark, the still dominant home of the industry, would suggest that there is considerable faith in its potential to keep capacity growing.

Clearly there are other barriers to be removed before it can be stated that such a mechanism can effectively drive a market into existence. The range of barriers to RE growth have been listed authoritatively elsewhere, as outlined in chapter one. Whilst the simple act of emplacing a mechanism to drive a market may be enough to overcome many of the financial and institutional obstacles, others, such as planning issues, may require other assistance if they are to be surmounted.

After creating a domestic market place, the next step is encouraging UK industry to take advantage of any market created. Inherent in this is that the industry must be capable of doing so, that is to say, new companies must be able to fulfil a number of characteristics in order to enter the market competitively.

The emphasis in the UK has been, and continues to be, centred on increasing competition and on reducing costs to the consumer, both direct and indirect, through the reduction of prices via market mechanisms and the reduction of subsidies, or at least by avoiding the imposition of new subsidies.

This requirement is immediately apparent from considering UK RET support, wherein both the NFFO and its replacement, the RO, have been founded primarily on competitive principles, and on minimising the financial impacts on the consumer. This historical and political commitment would tend to immediately rule out the possibility of the use of a REFIT-style mechanism – the central mechanism in most of the countries which have created the largest markets for wind energy so far – as inappropriate for the UK.

The nature of the dominating political philosophy in the UK has other implications for the creation of new industry. The nature of political governance does not easily allow for the directed support of industries through the provision of financial supports, as is the case in some countries. In this study, the example of Germany and its system of public sector governance is of particular note with regard to this issue.

The conviction to minimise regulation also impacts on the possible use of regulatory tools to assist the cause of domestic industry. It removes the possibility of a number of options for policy that have proved successful in countries such as Germany, Denmark and Spain, though not all the possible options.

Since some options are effectively outside the purview of the UK; what must be addressed are those options which might be both politically acceptable and technically feasible.

Vogel has suggested that the UK is traditionally poor in using regulation to grant domestic competitive advantage, though using the term 'regulatory subsidy'. Vogel suggests that this is due to the separation of sponsorship and regulation across a range of bodies, as they apply to any particular industry, with the result that regulation cannot be properly integrated into industrial policy (Vogel 1997).

What has been a constant factor in the policies of other countries with a successful wind turbine industry is that, in each case, there are evidence of policies aimed specifically at aiding domestic companies to capture some portion of the domestic market.

The 1995 statement of the position of the UK Government, railing against the benefits of protectionism in the home market due to the lack of availability of such subsidies as a form of international support, coloured UK policy, and may continue to

have an effect. It seems likely that the statement summed up what had been policy for some time before the statement was made. This position has undoubtedly had an effect on the industrial development of RET industries in the UK.

#### 9.4 Future UK Renewable Energy Industry Policy

As has been noted, policies to assist the creation of a market are not the same as policies to create an industry, though one is the natural precursor to the other. Similarly, the barriers to the use of new technology will not be identical to the barriers to development of industrial production of that technology. Policies which address the first of these may not specifically address the second, and such policies might effectively invite non-domestic industry to exploit the opportunity they create. Both of these observations are important as awareness of both issues should inform any decision regarding choice of policy.

The inevitable expansion of offshore wind may offer the opportunity to side-step many of the institutional barriers that apply to wind energy in the UK, particularly relating to siting and planning issues. Onshore projects however still seem to be expected to fulfil a significant portion of the new capacity which will be required to meet the increases in renewable energy demanded by the RO, most notably in the early years of the mechanism.

There has as yet been no political commitment to radical change in the planning process for wind turbines, as was the case in Denmark, and to a lesser, though still significant, extent in Germany and Spain. Again such issues essentially tend to be barriers to the development of the industry, and not specifically to the creation of industry. However, there may be some potential for the use of a planning permission mechanism to grant advantage to applicants using turbines from particular sources. Spain, or more particularly some of the Spanish regions, apply variations on

such a policy, with strong results for the stimulation of manufacturing within their borders. Undoubtedly, the creation of such a significant market for wind in Spain as has been seen, would have drawn manufacturers to the country anyway. The official imposition of a planning policy based on regional sourcing of equipment however, has ensured a minimum level of facilities within regions. It seems likely that this helps to increase the acceptability of the use of the technology, as well as to create a greater political will to continue with the use of the technology, thus helping to perpetuate the growth of the industry. The British Wind Energy Association agrees that this may be a potentially useful method for securing more of the economic and social benefits of wind energy and thus for greater acceptance of the technology. It notes though, that the profitability on individual turbines, and on small wind farms is not significant to justify a high level of community support. However, the potential still remains if the award of large scale contracts could be linked to siting of manufacturing facilities.

In the simplest economic analysis, the instigation of the RO itself should act to drive an increase in industrial capacity. As has been noted, primarily in chapter seven, but also in general terms in chapter three, there are a number of possibilities for how this increase will manifest. The demand can be met by UK manufacturers producing equipment in their domestic marketplace, by non-UK companies choosing to locate in the UK, by non-UK companies importing equipment from elsewhere, or by a mixture of these three. As has also been noted, the economic and social effects of each of these will be different. From the point of view of the UK as the provider of the subsidy which creates the demand for wind energy generated electricity, the least desirable option is to have the demand largely served by imported goods. This means the least improvement in employment, the creation of secondary industries, the



balance of trade and the minimisation of likely future investment in the UK from company profits.

The second option, of encouraging non-UK companies to develop manufacturing facilities in the UK, is obviously more desirable than the first option. It would also seem to be relatively easy to achieve. Many industry analysts suggest that merely creating a market for sufficient volumes of turbine equipment will be an ample stimulus for drawing in established manufacturers, and this is supported by evidence from Germany, Spain and the US, and to a more limited extent, China and India. Representatives of a number of major manufacturers have stated that they would be likely to commit to manufacturing in the UK, or anywhere else, should a commitment be made to policy demanding the installation of sufficient volumes to make doing so economic. The capacity of wind energy likely to be required to fulfil the obligations of the RO, are likely to be in excess of those volumes required by at least some major manufacturers, subject to the availability of sites able to produce electricity at prices below that of the RO price cap.

It has been demonstrated through practical application that the level at which companies decide it is economic to establish manufacturing facilities in a particular location can be strongly influenced by the application of particular policies. The policy established by a number of Spanish regions, which demands that a minimum level of manufacturing occurs within a their region before a contract is awarded, has acted to ensure the siting of a number of manufacturing facilities. This in turn has led to the stimulation of support industries, the creation of a significant number of employment opportunities, as well as to a source of funds for local governments and farmers who permit the use of land for turbine siting. Such a policy for awarding contracts also has the potential to be used as a tool for favouring domestic or local

industry in any place where it is awarded, either directly as a matter of policy, or indirectly, as it is more likely that any local company will already have its manufacturing capacity established in the locale.

One of the elements that is essential to stimulating investment in the establishment of manufacturing plants, is the perception that a policy demonstrates a long-term commitment to increasing the use of the goods manufactured. This is key to convincing both new domestic entrants to the industry that the market is worth initial investment and their entry, and to convince non-domestic suppliers that the capital outlay will bring sufficient savings when compared with otherwise avoided costs.

The UK, as has been established, has refused to introduce policy directed at protecting a UK based wind turbine industry. In some ways, it can be argued that there is a dichotomy at the heart of UK policy on wind energy. As has been pointed out in earlier chapters, there is the potential for two forms of protectionism to be at work in the creation of new industries, or new industry opportunities. The first is that, in order for wind energy generation or any other new form of energy generation to prosper, it must be protected from established energy interests, in order that the technology can develop to the point when it might become competitive with these other interests. Such policy is generally justified on the grounds that there are gains to the public good over and above the simple economic interests; in this case, these are the environmental benefits.

The second area of protectionism relates to national industrial policy. This is the area one which is of most interest in this research. Such policy is aimed at shielding domestic companies from fair and open competition with other, non-domestic, companies in the same industrial sector. There are effectively two

approaches to this, one policy strand is to subsidise the domestic industry through guaranteeing its markets, the other acts to increase the costs of non-domestic actors in order to reduce their competitiveness in comparison with domestic actors. As has been discussed at length in chapter three, protective practices are unattractive in pure economic terms but are central to the industrial policies of many nations, which compete to outdo each other in applying regulations protective to their domestic industry within their borders whilst attempting to minimise the barriers their own industries face in other administrations. The potential for the use of mechanisms which create competitive advantage for domestic concerns is central to this research, most specifically with regard to developing new UK renewable energy industries.

The UK has long claimed that the basis for its policy regarding wind energy, and renewable energy generally, has included both the desire for the environmental benefits, and a commitment to developing new industries based on the opportunities presented by any new technology developed to exploit them.

In order to achieve the end of protecting the environment, those responsible for UK policy have been willing to put in place practices which protect renewable energy industries from competition with other, more established, energy sectors. However, they have refused to engage policies which exhibit the other form of protectionism, that is providing domestic competitive advantage within an industrial sector. There is some justification for the application of policy in such a manner. Protecting an industry sector which provides goods with environmental benefits can be justified from two perspectives. In economic terms the generation of a public good has long been established as sufficient reason for the provision of public support. From a legal perspective, a regulation with an environmental justification is legal in that it conforms to an allowed exception from various trade agreements into which the

UK has entered. Nevertheless, with regard to renewable energy, the UK has refused to apply such policy, even where its competitors have done so. In a perfect market this could be justified as in the best interests of both consumers and industry. Where this argument falls down in practical terms is that the policies adopted by other countries to stimulate growth in their domestic industries may not have been subject to the same considerations, as these other nations have been willing to back their industries at home, and even to some extent overseas, through such policies.

The essential conclusion to be drawn from this, and a central conclusion of this research, is that, in order to access the wind turbine manufacturing sector, the UK needs to introduce policy which creates competitive advantage for UK companies. This is necessary to mitigate against the advantages afforded by such policies to other nations in the sector. The same lesson may also prove useful to the development of other RET related industries in the UK, as will be discussed in chapter ten.

Such policy has proved to be essential in each country which has successfully established a wind turbine manufacturing industry.

As described in chapter three, the options for regulatory measures which might offer competitive advantage can fall into a number of categories. To recapitulate, these are;

- Those which would be legally unacceptable but which are unlikely to lead to complaint for political reasons; generally to avoid retaliatory complaints.
- Those yet to be legally judged as unacceptable, including those to which it is difficult to apply legal obligations.

- Those which may be illegal within the constraints of international trade legislation but which are initiated to gain advantage whilst usually slow legal processes are brought into effect by the relevant bodies.

Policies might then also be divided between those with and without a fiscal aspect.

There are examples of policies from Denmark, Germany and Spain, as well as from other countries not detailed in the case studies in this research, which fall into each of these categories.

Key to employing policies aimed at creating competitive advantage is identifying how a policy will function in reality, whether it is likely to be subject to legal challenge and, more pointedly, whether such a challenge would be successful. These factors should all usefully inform the choice of policy introduced in support of stimulating industry.

Additionally, it may be possible that some policies which have proven to be beneficial in creating competitive advantage for wind turbine manufacturers in the past, may prove to be ineffective if introduced presently, due to the changed circumstances of the industry. Some policies of this nature may also be less acceptable, or less tolerated, due to its increased size.

### 9.5 Policy Options for the UK

The UK policy of minimising regulation, and of maximising competition, to the supposed advantage of the consumer, may limit the options available.

With regard to gaining competitive advantage, or having the potential to do so, many of the policy options based on direct fiscal support to have so far been enacted in countries which have successfully nurtured industries, would seem to be

inappropriate in the UK for one or more reasons. The use of the NFFO and the imminent uptake of the RO is likely to place limits on the use of any additional instruments with a financial component, and the historical preference for competition based mechanisms also tends to mitigate against them. These considerations are also likely to impinge on the use of other possible financially based instruments, though it is obviously not possible to rule out the use of some other instrument as yet devised or proposed.

In more general terms however, the use of some of the fiscal instruments discussed above may still be pertinent in other countries wishing to advantage any new wind turbine industry, though obviously the relevance of particular policies must always be viewed in the context of the particular NFS of the nation in question.

One option is to follow the original German path of stimulating both a market, through initiating a programme of subsidising a fixed increase in capacity, and thus hopefully a domestic industry, by specifically directing the subsidy to it. This would be likely to be inappropriate for a number of reasons. At the present stage it would require an about face in UK policy from the competition-based nature of the NFFO and the proposed RO. In general terms, this might still be an appropriate policy option for a nation attempting to access the industry and which has little history of using wind energy, or which has had similar policy instruments in place previously. Specific to the UK though, the use of a programme aiming to increase capacity through direct subsidy is likely to be deemed out of touch with the modern realities of the market, and not in the best interests of the consumer.

A similar option for stimulating a market, which has been employed in a range of nations, is the placing of an obligation on utilities to develop a specified amount of wind energy capacity. In Denmark, this was successfully used as a stop-gap to bolster

the domestic market and thus domestic industry during a period of international market failure, though it could be used at any stage in the market stimulation process. There are some similarities between such a policy and the RPS mechanisms currently in use in Denmark, and to be introduced in the UK. In both of these countries though, the renewable portfolio standard (RPS) obligates suppliers rather than generators, which is where this alternative places the obligation. Thus with this policy, the obligation is directly on an increase in capacity rather than having this as a secondary effect of creating a market for electricity. Additionally, this kind of obligation is technology specific, rather than allowing a competitive process to decide which technology is used. The policy of obligating generators to install capacity did work to maintain the Danish domestic industry at a time when the industry as a whole was vulnerable, and conceivably could assist the Danish domestic industry again, should the demand there lessen, though this seems unlikely to occur given the RPS mechanism now in place. Applying such a policy might be less use to domestic industry in the UK, if it was possible at all. The deregulated – and still geographically diverse – nature of British generators would be likely to lead to problems with laying down such an obligation. The forthcoming RO driven market stimulation policy might make the addition of another market subsidy scheme appear divisive, and having two policies with different levels of competition, and which introduces extra costs at two separate levels in the supply chain, would be likely to be regarded as introducing too high a level of regulation. Specifically with regard to stimulating UK industry, it seems likely that it would be difficult to stop contracts for turbines going overseas. It is thus suggested that this policy would not be beneficial in the UK.

A fiscally-based policy which has proven successful, and which continues to do so, is the system of granting ‘soft loans’ that has been in place since the early

1990's in Germany. As has been described in some detail in chapter five, the German national financial system (NFS) is particularly suited to providing cheap capital to those areas of technology that it wishes to develop. Provision of such funding, through investment banks which are essentially government directed, means that German efforts can be concentrated on developing particular areas of technology, rather than allowing the market alone to decide. In this way technologies can be chosen which offer social and political benefits in addition to financial gains. The German Government can then exercise greater control over how a new industry develops, and can work to ensure that a greater portion of the benefits remains within the country.

Whilst this system of providing cheap capital would, on the surface at least, appear to be quite simple to emulate, in many ways, it can be regarded as very much a reflection of the German NFS. Mitchell's 1994 analysis (Mitchell 1994) of the German NFS points out that some of the mechanisms are 'unusual but helpful', and also points out that, along with Denmark, Germany has an NFS which more easily makes funding available to small projects or individuals. Mitchell concludes that the German 'NFS co-ordinates with the Government support mechanisms', a quality which she concludes is also true of Denmark, but which is notably absent in the UK. Mitchell further concludes that the NFS of the UK thus acts as a barrier to RET deployment. Mitchell also notes that the NFFO did little to address the problems inherent in the UK NFS. It is difficult to see how this will change under the RO

Introducing a system for soft loans in the UK similar to the German system would help to remove both the barriers to the expansion of the market by increasing the opportunities for investors, as well as offering the potential for establishing competitive advantage for any UK manufacturers in the domestic market. It would,



however, seem to be a highly unlikely development. The UK system of governance would not readily take on board such a mechanism, in that it represents a very radical change from the present NFS and in political terms, and would be likely to be regarded as demonstrating an unacceptable level of interference in the operations of the marketplace.

It should also be noted that the mechanism may be more useful as a tool for gaining competitive advantage in a market which is already dominated by domestic industry. That is to say, it is likely to be easier to maintain market share using such a mechanism than to try to expand it, as this is less likely to attract accusations of bias, since the ability of domestic market to service a particular fraction of the market will already have been proven.

With regard to the UK, the limitations on the potential use of fiscal instruments to gain competitive advantage for a potential domestic turbine industry tends to rule them out, at least on the basis of the present evidence. One exception to this is the provision of a limited amount of grant capital to be made available to support the initial expansion of offshore wind and of energy crops. The Crown Estate has approved pre-lease qualification for developers of the eighteen offshore sites identified by the UK Government as being desirable for siting (Rajgor 2001). The offshore contracts are however still subject to public consultation and final government approval thus some potential may still exist, though such direction remains unlikely. As only four of the eighteen sites will receive grants, it is possible that these could still be directed to developers which favour the purchase of UK manufactured equipment. However, given the level of transparency that the awarding of grants is likely to be subject to, it is difficult to comment on how likely it is that this will happen.

Certainly, given the UK's emphasis on market led mechanisms, it is unlikely that such a mechanism would be acceptable politically in the UK, or that it could be established with ease. The introduction of grants for the stimulation of offshore wind energy in the UK might be seen as a little surprising. However, the UK Government has repeatedly emphasised that such availability will be strictly limited, and thus the role they play will also be limited. These restrictions on the use of grants as a mechanism further underline the unwillingness of the UK to employ instruments which are not based on competition.

The restrictions limiting the use of fiscal instruments to support the expansion of UK renewable energy markets and industries means the possibility of the use of non-fiscal instruments for the creation of competitive advantage for UK companies must be considered.

#### 9.6 The Potential for Non-fiscal Instruments in Creating Competitive Advantage for a UK Wind Turbine Manufacturing Industry

There are clear advantages to the use of non-fiscal instruments to gain competitive advantage. They can largely be instigated as a form of market regulation with a primary aim of altering the market, rather than stimulating a market as is more generally the case with fiscal instruments in this context. This attempt to alter the market can often be justified for reasons other than the straightforward growth of the market or of the industry, such as improving the operational efficiency or safe performance of the technology. This has been evidenced by examples from the case studies detailed in chapters four to six.

Non-fiscal instruments with the possibility of being applied to bring competitive advantage may fall into two categories in that they may be applied both to

encourage new domestic industry entrants or to offer older domestic actors the chance to expand market share.

A number of non-fiscal policy options with the potential for creating competitive advantage for domestic manufacturers have been adopted in Denmark. Regulations have been brought into place which effect both the quality standards that turbines must meet to be sold in Denmark, and the technical features that wind turbines must include to be licensed for sale on grounds of safety. Both of these regulations have the potential to offer competitive advantage to domestic manufacturers, without unduly affecting their performance outside of their country. Standardisation of technology through the enforcement of licenses to sell particular goods within a country can be carried out in a number of ways. The use of a test centre through which licences have to be issued can be the base of one methodology for such a policy, as well as being a useful base for national R&D efforts. Risø in Denmark provides an excellent example of the use of such a test centre, and there remains the potential for the use of such a centre in the UK, both for wind and to aid the development of industries for other RET's, as will be discussed at greater length in chapter ten. As has been noted in earlier chapters, the generally non-controversial nature of government support for R&D removes much of the potential for objection to such a centre. The use of safety legislation is slightly more controversial but can, in general terms, be regarded as a public good. By applying any legislation on safety or operating standards to all manufacturers much of the case against their introduction can be circumvented. However, by introducing regulations which implicitly favour the technology of domestic producers it is possible to raise the operating costs for non-domestic producers, and to thus render them less competitive. Obviously this is dependent on having domestic industry already in place, and for the technology they

produce to already exhibit significant differences from that of non-domestic producers, or at least some fraction of these. It also calls for some reasonable degree of dialogue between government and the industry in order for the former to be aware of the needs and specific conditions of the domestic industry which differentiate it from its competitors.

The Spanish approach to regulating the wind turbine manufacturing industry, at least at regional level, has been somewhat novel. Compelling developers to purchase a certain fraction of the generators they install from local sources ensures the capture of employment opportunities locally, thus bringing both social and economic benefits to the regions planning high levels of wind energy exploitation. Such a system also carries the potential to stimulate local entrants to the manufacturing process, and additionally the system of oversight by the regional governments offering the contracts offers easy potential for directing contracts preferentially to domestic manufacturers.

This approach to regulation would be likely to be regarded as ethically, and more importantly legally, contentious in many jurisdictions. The potential second aspect of such policy, the possibility for protection of domestic manufacturers, is obviously vulnerable to objections from those actors that such a policy disfavours. The use of such contracts in the UK is also largely unknown, and thus the potential for the use of such a policy has so far not been relevant. The switch of emphasis to favour the use of offshore wind energy in the UK, with the UK Government announcing the future availability of contracts for eighteen major offshore projects may mean that this changes.

The first aspect of such a policy, that of enforcing the local establishment of production facilities, might also be subject to objection on the grounds of free trade

and with regard to restricting free movement within the European Union. However, as has been mentioned in previous chapters, even where such a policy does infringe on rights relating to free trade, it is often left to the industry actors who suffer to raise the issues with their respective governments. There is evidence that, by tying the policy to the other mechanisms which support the increased installation of the particular RET, it is possible to create a situation wherein it is in the interests of all the manufacturing actors to avoid raising issues which might end the market as a whole, thus losing them access to that part of the market which is open, and in which they might hope to secure some business. The corollary of this is that, if such a policy is to be put in place, it is essential that some significant part of it remains open to actors and is not completely closed to non-domestic market entrants.

The potential to introduce national or regional renewable energy policy which can link market stimulation with the creation of domestic competitive advantage is clearly one that can apply with respect to a range of different policy options. This is thus another factor which can usefully inform the policy creation process.

Germany does not appear to rely on non-fiscal mechanisms which provide significant support to renewables, though rules relating to accessing the grid might be used to offer some advantage. It does have considerable potential to provide competitive advantage for domestic manufacturers through the direct use of fiscal instruments.

One interesting general instrument with the potential for protectionist application, and which may have been applied with regard to the wind turbine industry is the US policy instrument known as Section 337. This piece of legislation was introduced in the US as part of the 1930 Tariff Act and with the intention of protecting the rights of US patent holders through the actions of the statutory body it

created, the International Trade Commission (ITC). Despite its name, the ITC is a solely US based institution which exists to protect the interests of US companies. It has the power to exclude imports to the US which it upholds to be unfairly traded as a result of patent infringement. Whilst this would seem to be perfectly defensible, Bhat (Bhat 1996) has shown that the number of complaints brought under Section 337 can be related to the number of patents a country has been granted in the US as well as to a range of economic indicators, such as the consumer price index, GDP and import-to-export ratio. Bhat suggests that the number of complaints each year is indicative of the pressure for technological protection from within the US. Bhat refrains however, from concluding that Section 337 is being used to block high technology products from entering the US and thus improving the competitiveness of US industries. This does not imply that this is the case however, though it would certainly be technically possible to use the mechanism protectively if this was required.

With specific regard to the wind energy industry, it was Section 337 that dealt with complaints made regarding Enercon by first Kenetech, and then Kenetech's subsequent purchaser, Zond. The result was that Enercon was banned from selling its variable speed technology in the US until 2011 after the ITC ruled that their use infringed the patent rights of Kenetech technology.

Whilst the use of an instrument such as Section 337 is one that is available to all governments, alongside international agreements such as exist within the EU, it is a more general instrument rather than being specific to a single industry. Any use of patent protection relating to wind energy is likely to come from regulation already in place and is likely to be difficult to turn to creating competitive advantage for particular actors. Specifically with respect to the UK, such a policy would anyway require that UK companies already held patents relating to wind energy, and thus

would likely be useless till an industry has already achieved a certain level of establishment.

A general area central to supporting the uptake of new technologies, as described in chapter three, is government procurement. Government procurement is relevant both with regard to market stimulation and the creation of competitive advantage for favoured manufacturers. There are a number of recent examples of government bodies purchasing ‘green power’ in the UK alone, and evidence that this has stimulated demand for new generating plant, largely wind turbines. Clearly a distinction has to be made between the government purchase of electricity from green sources, which acts to stimulate a market for RET indirectly, and the government purchase of the actual technology itself in order to power its facilities, which can both stimulate the market for the technology and which more easily has the potential to be turned to a tool to support domestic manufacture of goods.

The WTO suggests that competitive advantage might be gained through “Measures to this effect [which] may be either explicitly prescribed in national legislations, for example prohibitions against the purchase of foreign goods or services or from foreign suppliers, preference margins, set-asides and offsets, or in the form of less overt measures or practices which have the effect of denying foreign products, services and suppliers the opportunity to compete in domestic government procurement markets, including excessive use of single or selective tendering, non-open technical specification requirements and, in particular, lack of transparency in tendering procedures including contract awards” (WTO 1999). The potential for application of government procurement has been curtailed to a considerable extent by the WTO Agreement on Government Procurement (GPA) which ‘establishes an agreed framework of rights and obligations among its Parties with respect to their

national laws, regulations, procedures and practices in the area' (WTO 1999), and to which the USA and the Western European countries are signatories. The GPA is supposed to ensure that supplying governments with goods and services is open and fair with regard to all who tender for its business, though there are limits on its application, and minimum thresholds for transactions to which it applies. As with the other instruments discussed here, there is still the potential that infringements might not be subject to complaint where an instrument is judged not to be totally against the interests of relevant parties. Thus there remain opportunities for the use of government procurement as a tool for gaining competitive advantage.

There are a number of examples of direct procurement of renewable energy technology around the world, though none as yet in the UK. In the US, the military have investigated the use of wind turbines, as well as other power supplies such as photovoltaics to power remote installations or small mobile equipment. The nature of wind energy technology however, alongside the electricity supply industry structure in the UK means that it is unlikely that there will be significant opportunity for the government to directly purchase wind energy technology for its own uses. This is not necessarily true of other RET's, as will be discussed in chapter ten.

### 9.7 Possible Policies to Stimulate a UK Wind Turbine Manufacturing Industry

The first step in developing a UK industry is to establish that there is a potential opportunity for such an industry to exploit. Chapters six, seven and eight establish such a possibility. Once it has been accepted that this is a possibility, policy needs to be adopted to encourage an industry to develop. Key to such development is the establishment of a domestic market for the industry to exploit and which can act as a base for international expansion. Whilst there are a range of legitimate mechanisms for developing such a policy, these do not necessarily benefit domestic industry. Thus



the adoption of at least one mechanism with the potential for allowing domestic industry to gain competitive advantage over non-domestic rivals may be necessary. There is evidence that no country which enjoys its own domestic manufacturing base for wind turbines is without some mechanism which acts to protect these interests.

It is important to note a number of specific protectionist policy options may not be open to the UK, dependent on a range of cultural, political, social or financial reasons, or for a combination of these reasons. This will effectively rule out some of those policies which have proven to be successful elsewhere. It should also be noted that some of the policies introduced in other countries, particularly Denmark, will not be available in the UK, as they are no longer appropriate in terms of how the industry has developed, and how the context of the industry and of entry to the industry has changed, since they were originally put into practice.

It seems likely the use of financial mechanisms outside the RO will be difficult to justify politically, particularly if one aim of such a policy is to engender advantage for domestic companies. Thus the wisest course may be to leave the RO as the sole significant financial mechanism and as the chief stimulant of a market, and to focus on non-financial mechanisms for driving UK industry.

One consideration for UK policy might be the setting up of a test station concerned with R&D for renewable energy technologies and for the checking of any operating standards that might apply with regard to the sale of RET in the UK. Such a facility would also be likely to benefit renewables other than wind, as will be discussed in the next chapter.

Specifically with regard to aiding a UK wind industry, the applications may presently be somewhat limited. Without a UK industry already established, it is naturally not possible to choose specific aspects of a UK design to specify as a

standard, and to use this to lever up the costs of other manufacturers. For any policy relating to UK industry to be effective, there has to be a UK industry. For this to occur, there needs to be a market, which the RO has created, and a belief by British actors that they can access that market, that is, that there is both general and specific opportunity.

The next stage following the creation of the RO and a market, is to act to encourage UK companies to become involved in the industry. This may embrace some level of difficulty given the poor history of UK manufacturers in the field. As has been pointed out repeatedly in this and previous chapters, the nature of the wind turbine industry has been subject to change throughout its history. The companies involved have grown bigger as the demand for their products have grown. At some point, possibly not too far into the future, the industrial phase is likely to change to a mature stage. This will have a number of implications as have been discussed in depth in chapter eight. One important characteristic of companies successful in this mature phase is a high level of vertical integration, necessary to capturing the narrow margins which exemplify the phase. New companies wishing to access the market for large wind turbines are likely to have to be of significant size, in order to be able to afford the level of investment that will be required to both develop their own technology, and to operate the composite parts of an integrated company.

Thus, if the UK is to encourage domestic operators to attempt to access the industry, its efforts should perhaps focus on large scale engineering companies with the means to support their efforts. This is further supported by the recent interest of the large multinational ABB, and to some extent by the involvement, and indeed success, of some large Spanish Corporations in the industry in Spain. Recent comments by the President of the European Wind Energy Association (EWEA),

Klaus Rave, are also of interest in connection with to this issue (WD 2001). In reply to a question as to whether more manufacturing companies are needed to service the worldwide market, Rave comments that it is bigger turbine companies that are needed, not additional ones, on the basis that it is these which will be able to make the necessary investments. The comment is interesting in that, whilst Rave suggests that new companies are not needed, any large companies which do decide to join the wind turbine industry would also be capable of investment on a significant scale. Additionally, they might also have the benefits inherent to new entrants to the industry outlined for successful entrepreneurs to the mature phase of an industry as described by Low and Abrahamson, and as discussed in detail in chapter eight.

As a partial aside, one area that may prove to be of particular interest relates to the likely growth in offshore wind energy. The expansion of interest in offshore wind is mirrored in a number of European nations. As yet, there are no national or international standards in place relating to the support structures that are employed as the foundations for offshore wind turbines. Additionally, this aspect of the industry is relatively undeveloped in that the market is more recent than that for the turbines themselves. Attracting new companies to service this new industry might thus be easier to achieve, and since there is less established competition the market may prove easier to capture. For the same reason, assisting the capture of the domestic market with policies designed to give new domestic entrants competitive advantage might also be easier. The use of specified standards might be one option for achieving this, dependent on the level of differentiation that can be made between the designs of domestic and non-domestic manufacturers. Again, the use of regulatory instruments in this way would be dependent on close communication between government and industry.

Another possible option for creating competitive advantage for domestic industry in the UK concerns the use of planning permission.

One interesting aspect of the planning process in the UK is that planning inspectors and committees are specifically directed to take into account the benefits and demerits of any proposed installation on both the local and global environment (UK Department of the Environment 1993). Frequently, proposed developments, such as for a supermarket for example, will involve a commitment on the part of the developer to enhancing some aspect of the local environment, a mechanism known as 'planning gain'. The relevant planning inspector and committee are obliged to consider all the benefits to the locality, including employment created through the development. In many ways, this might be compared with the situation in Spain, in that the policy for awarding contracts there is linked to an assessment of both the social and economic benefits of wind turbine installation, though the purview of the planning process is not usually quite as wide as the tendering process in Spain would appear to be. Nevertheless, there may be some potential to use the planning process to ensure that at least some of the benefits of local manufacturing are gained in relation to the siting of turbines, though the legality of such action would likely to be open to question. The use of the planning process in this way, could obviously be applied both with regard to creating domestic competitive advantage, or more transparently, as a straightforward effort to capture manufacturing capacity for the nation or region concerned. It should be noted however that the competitive nature of the wind energy market in the UK means that margins in the turbine development industry are narrow in comparison with other European nations, and thus the level of planning gain that a developer could be expected to provide in relation to a project before the project became economically unfeasible is likely to be low.

Clearly though, if the planning process is to be used in such a way it is going to be necessary for the UK Government to sort out the problems with regard to how the present regulations, and their interpretation, affect installation proposals at the moment. The present uncertain nature of likely planning policy in the UK means it is difficult to adequately comment on the likelihood of mechanisms of this kind being of use in the UK in the near future.

In turn this provides a further example of the way in which changing policy to assist the growth of the market for RET can also be used as a way to assist domestic industry.

The use of a test station to achieve a range of goals relating to wind energy, as well as assisting with the increased uptake of other technologies, would seem to be the strategy which might best serve the growth of a UK industry, and which can be most easily achieved. In addition to providing the advantages discussed above with regard to the large wind turbine generator industry that has been the focus for this research, such a station might also effectively facilitate a range of support industries around the central turbine industry.

The possibility of utilising the planning system opens up a further option that utilises much of the present policy situation to provide a course of action which might be used to favour UK industry, but with less complication, and which might also be able to secure the location of manufacturing in the UK.

It should be noted that the policies discussed here are not exclusive, it is eminently possible that there are other policy options that have not been broached here that would provide an effective advantage for UK industry. Equally, there may be policy options for other countries which would provide their industries with competitive advantage, but which might not be applicable in the UK.

A further policy instrument which has yet to move into full operation, but which may have important implications in terms of UK industrial policy for environmental technologies, is the establishment of The Carbon Trust. As has been described in chapter seven, the Trust exists to encourage the greater use of energy efficiency and industrial carbon technologies, as well as to encourage the development of 'low carbon technologies nationally and internationally'.

This final aspect is of particular note. As detailed in chapter seven, the Trust is funded from the imposition of the Climate Change Levy (CCL) and, at least in theory, has the potential to operate in a fashion similar to the publicly-owned German investment banks. In terms of actual operation however, there may be significant differences. The loans provided by the German investment banks are provided to develop SME's as part of focussed efforts to help establish new industries. The specific industries which are supported are chosen by the German Government. The financial support offered through the Carbon Trust appears to be unlikely to be directed with the same commitment to aiding the development of particular industries, and current indicators suggest it will instead supply funding on the basis of how much carbon can be mitigated calculated against the level of investment required. Whilst this approach may seem more geared to specifically addressing the most cost-effective remediation of the maximum amount of greenhouse gas emissions, by failing to address the potential for the applicability of funding to the creation of new industry, it may miss the opportunity to leverage much greater environmental and social gains in the future.

Whilst the commission of the Trust is clearly a positive step in UK environmental policy, this lack of specific government direction, if indeed this is actually the case, may dilute its effectiveness as a force for increasing UK

environmental industry. There are though, it must be noted, reasons behind this lack of government direction. The development of the Trust, and its stated goals and methods, are the result of considerable input from industry upon the CCL, and the methods by which the funds gathered through it are redistributed. The result of this has been that industry has effectively forced policy which directs the funds to be disbursed on the presently stated basis. Indeed, there is a strong case to be made that this is fair.

In terms of industrial policy however, the development of the Trust in this way might be regarded as a missed opportunity to aid the UK in developing new businesses and new industries more effectively. In some ways, the unwillingness to follow the German pattern may be regarded as typical of the UK opposition to the policy of government attempting to pick technological ‘winners’, and a reflection of a significant difference between the governance systems, and of the national innovations systems, of Germany and the UK.

There is a further codicil to the potential for the use of Carbon Trust funding to develop UK industries however, and to reconciling this potential with policy as it is presently stated. Clearly, the UK Government would experience political difficulty if it were to introduce a funding mechanism which specifically assisted UK companies in securing market share. It can not explicitly state that a mechanism such as the Carbon Trust is intended for such a purpose, even if that was the case. Thus, there is at least the possibility that this may prove to be the intention, or if not the specific intention, may turn out to be the case anyway. Clearly, it is still too early to ascertain what results the Carbon Trust will actually achieve, and this is likely to be an area requiring further study in the future.

Finally, it should be remembered that these policy instruments are considered within the context of the UK attempting to access the wind turbine manufacturing sector. It must be borne in mind that this is the most developed and mature of the new RET industries, and as such is presently the technology offering both the greatest economic rewards, and the highest level of competition. It may be easier to assess the lessons learned from the wind turbine industry both domestically and internationally, and to apply these to accessing and developing other new RET industries. Applying these lessons to exploiting markets for other RET's by the UK will be the subject of the following chapter.

#### Main Points in Chapter Nine

- The major conclusion is the suggestion that the possibility still remains that the UK could successfully stimulate a domestic wind turbine manufacturing industry.
- The Non-Fossil Fuel Obligation (NFFO) failed to provide a stable base for the development of UK manufacturing capacity. It did aid the development of overseas industry.
- The Renewables Obligation (RO) mechanism which replaces the NFFO mechanism has proven to increase installed renewable energy capacity but is not a proven stimulant of industry.
- The foundation of UK policy in minimising costs to the consumer as the primary function of any mechanism to stimulate growth in renewable energy capacity may not also be appropriate to stimulating the development of new industry.
- The UK's refusal to offer protectionist policies at home may preclude access to the wind turbine manufacturing industry, and may have future implications for accessing other renewable energy manufacturing industries.



## **Chapter Ten: Lessons for the Development of other Renewable Energy Technology Manufacturing Industries**

### **10.1 Introduction**

This chapter sums up the lessons that can be learned from the positive and negative experiences of the UK, and of the other countries which have been the subject of case studies in this research, with regard to wind power. The chapter then discusses how these lessons might be applied to foster greater success in developing competitive industries in other renewable energy technologies.

### **10.2 The Industrial Model for Renewable Energy Technology Manufacturing**

Weinberg (Weinberg 2000), in conference at the World Bank in March 2000, suggested that the industrial model for renewable energy technologies is likely to resemble that for the car industry. That is, particular companies may own the technology, but the costs of moving goods demands that the actual production of vehicles is carried out close to the market, irrespective of where these companies are located. Similarly, the sheer size of moving wind turbine components, or the large components for most other RET's, means that companies wishing to serve significant markets may be forced to locate their manufacturing centres close to markets in order to keep their transport costs down. This would seem to be borne out by the experience of the wind turbine manufacturing industry, where the development of any large markets for turbines, has seen the construction of appropriately local manufacturing plants to service them. There are a number of examples of this in practice. When programmes were introduced to encourage the use of wind energy in India, a number of major Danish manufacturers entered into joint operations with Indian companies in order to secure access to the market, and a number of production plants were set up to meet the demand. Similar processes have occurred in Germany,

Spain, to some extent in China, and in some US states were sufficiently large markets have been created to justify the capital expenditure on new plants. The recent announcement of the opening of a new plant in Scotland by the major Danish turbine manufacturer, Vestas, most likely in response to the offshore expansion of wind, is a further indicator of how market stimulation elicits a response which enables social and economic benefits. Clearly, the siting of car manufacturing plants also has a political aspect, with the desire on the part of the manufacturer to associate themselves with the social gains of such siting. This has the potential to also apply to manufacturers of renewable energy technology.

It is perhaps worth noting that some RET's, notably biomass and photovoltaics, may vary from this model. The more modular nature of PV technology may lend itself more easily to long distance transport than other RET's, whilst biomass has a different form of energy collection, has a somewhat different set of needs, and would relate to a different set of support industries to fulfil these. The sources for biomass energy are more diverse, including wastes from other processes, and the aspect of possible competition for fuel supplies may have significant implications for the way the established industry might operate.

It is suggested here though, that there is at least one aspect of the industrial model for wind turbine manufacturing differs from for that automobile production, and that this seems likely to also offer differences for other RET's such as tidal, tidal stream and wave energy. If we accept that a domestic market is essential for the growth of a domestic industry, and there is a considerable body of evidence to suggest that this is the case, then the growth of an RET manufacturing industry will be dependent on the availability of a renewable energy source to be exploited. Thus, the development and growth of a new renewable energy technology manufacturing

industry is likely to be limited to countries which have the relevant energy resources, and which are available to be exploited by the technology the new industry is producing. Whilst this is a relatively simple conclusion to be drawn from the information available, it may have important implications for countries with renewable energy resources. Particularly, it may be of significant consequence for those countries committed to encouraging the growth of industries aiming to exploit those resources, and to service the markets of those wishing to exploit such energy resources elsewhere.

As has been repeatedly emphasised in this research, the need for a domestic market is practically an essential precursor for the foundation of an industry. The initial development of the wind industry in Denmark, a country with one of the best wind regimes in Europe, was clearly linked both to the existence of the resource, and to its suggested potential as an alternative to energy sources perceived as less environmentally friendly, amongst other reasons. The perception that there is a need to maintain a domestic market to support the turbine industry in Denmark is further emphasised by the increasing shift to offshore wind, as available onshore sites become more difficult to find. Spain provides a further example, with wind energy exploitation originating in its windier regions, and with these regions remaining as the dominating areas for industrial growth. Germany, with its poorer wind resources, may already be beginning to experience difficulty in opening up new sites. This is underlined by the recent announcement that Germany, like Denmark, the UK and others, is to go down the path of extensive offshore development. It is suggested that the scarcity and comparatively low quality of onshore German sites has required the relatively high financial support of German wind energy development. This goes at least some of the way to explaining the continuing enthusiastic political support for a

REFIT-style support mechanism in Germany, that is, to ensure a domestic industry is maintained, if this support is seen in the context of a specific industrial policy.

The need for plentiful renewable energy resources as a basis for a domestic industry is important within the industrial model outlined above, primarily for its implications for the likely competition for any country developing new renewable energy technology. This is best demonstrated through a simple example. Energy systems reliant on particular and specific geographical characteristics, such as the flow of large bodies of water as with tidal, tidal stream and wave energy, are restricted to countries rich in the particular geography. The promising offshore opportunities for a number of RET's are, perforce, restricted to those countries with coasts.

The result of this is that the number of countries which can compete to create new technology, new markets and encourage new industry is limited. There are both advantages and disadvantages to this. Obviously there are limits to the number of sites, and to the markets for any new technology created. For a country with abundant resources, a reasonably high-tech industrial base and a commitment to policy aimed at supporting the development of new environmental industries, there should be significant potential. Whilst it is likely that only countries with the requisite natural energy resources will develop the appropriate technologies to exploit them, the converse of this is that the export markets for these technologies will also be limited. Two factors might help to shift this balance. The first is that the development of new technologies is much more likely to occur in developed countries than developing countries, largely due to the costs associated with technological development and diffusion and the greater availability of funds from different sources to meet those costs. Once the technology is developed it can be sold to these countries, though it is important not to overestimate these markets. There are lessons to be learned from the

wind industry, and to some extent from the photovoltaics industry, in that the rate of expansion in developing countries has often failed to meet the levels of adoption that have been expected (Hoffman 1985; Gay and Eberspacher 1994; Moore 1994; Dunkerley 1995; Cody and Tiedje ; Philips and Browne 1998; Siemens 2001).

The second factor regarding markets is that other developed nations may have some limited renewable energy resources not sufficient so that they might be able to justify the spending needed to back up the foundation of their own domestic industry, or for private backers to feel that it is worth investing in the attempting to build an industry. Once a technology is available in such a country these may become capable of being exploited economically but it must be remembered that it is companies not countries who must make the final decision to invest in trying to access an industry sector. In order for this to occur, the appropriate companies must exist, or at least actors willing to invest in new companies must exist. Secondly, these companies must be convinced that there is opportunity to gain access to a sector. Governments have a hand in each of these, both with regard to encouraging industry and creating opportunity, and at least to some extent due to the nature of their constituencies, in securing markets for their domestic industries.

The situation outlined above may be one in which the UK might be able to create new industries for some new RET industries, where it would have the advantage of having a high level of available natural resource, and where it would not have too many competitors from other nations with both the interest and ability to help drive the creation of a hi-tech industry. Particularly of note in this category, with regard to the possible future development of RET industries in the UK, and fitting in with the industrial model outlined above, are wave and tidal stream technologies. The UK coastline offers plentiful resources in both of these and potential competitors are

limited, though there are a significant number of markets outside the UK with the potential for useful sales.

One lesson of significant importance that can be taken from the example of the wind turbine industry, is that the nation which is first to create the conditions to establish a domestic manufacturing industry, and sees an actual industry develop, claims a significant advantage in seizing the long term social and economic benefits of that industry. The additional costs of catching up, or in gaining even limited access, have been demonstrated by both Germany and Spain with regard to wind. The converse of this is that any country attempting to become the first to develop and exploit a new technology risks failing to do so, and must bear the costs of that failure.

Essentially, investment can be regarded as a gamble. With regard to renewable energy technology, it is a gamble that the UK has been historically reticent to make. Whilst the UK is often regarded as having a poor history of choosing technologies to attempt to develop into industries, there may be additional reasons why it has not been keen to commit to early support of RET's. A central reason may be that a typical analysis of technologies such as wave and tidal stream have often suggested that they are unlikely to be economic in the short term, or has described them as 'long shots' for the future. Both tidal and wave energy were classified as being subject to a 'Watching Brief' in Energy Paper 62, with no deployment expected up to 2025 except for a minimal amount of shoreline wave (DTI 1994). The supporting analysis for the 'New and Renewable Energy: Prospects in the UK for the 21<sup>st</sup> Century' document upgraded this to suggest that tidal stream might expand between 2005 and 2010 to provide in the area of 322MW of capacity, though it also predicted that no commercial wave energy exploitation would occur by 2010 (DTI 2000a). Three contracts for wave energy were offered within the third Scottish

Renewables Obligation Order Three (SRO3). The three projects range in size from 43kW to 500kW, and are thus relatively small. One of the wave projects is now generating. The contract prices for the three projects range from 5.95p/kWh to 7.0p/kWh – this compares to prices ranging from 1.89p/kWh to 7.0p/kWh for the SRO3 Order as a whole (OFGEM 2001).

It is not specified what is expected to stimulate the expansion of tidal stream energy and thus it must be assumed that market forces, and the small amount of R&D funding that has so far been provided for prototypes, are expected to be the driving force; it is unclear whether factors such as the climate change levy exemption, and the introduction of the RO, have been taken into account, and whether it is possible to do so with any degree of accuracy.

### 10.3 The Need for a Long-term Commitment to Policy

One element that has also been demonstrated by the Danish experience with the development of its wind turbine manufacturing industry is that it required a long-term commitment on the part of Danish policy makers and legislators. In their report concerning Wave and Tidal Energy, the House of Commons Select Committee on Science and Technology emphasised that it regarded this commitment as offering important lessons for UK policy. The report suggests that there were three factors concerning Danish wind energy policy, other than financial support, which enabled Denmark to capitalise on its early development of wind technology. These can be summed up as;

- long term commitment to improving the technology;
- the introduction of long-term incentives for buyers and sellers in order to create a continuing market;
- long term political commitment.

The practice of each of these is described in some depth in chapter four. One conclusion of this research is to concur with the assessment that a long term approach to all aspects of policy is likely to be essential to UK efforts to create competitive international RET industries. It is suggested that it would be in the interests of the UK to evolve a strategy which addresses the creation of self-sustaining markets for the technology, and assists the stimulation of industry such that investment in the development of these markets can be reclaimed with both social and economic gains. As with the House of Commons Report, these conclusions are, in part, based on the success that Danish political support efforts have engendered in the wind turbine industry, as well as the presentation of the commitments at both national and regional levels in both Germany and Spain.

The House of Commons Select Committee report also notes the advice the Committee had been given, that the UK is the present technological leader in both wave and tidal stream energy technology. On this basis, it proposes that policy with long term intent be enacted as soon as possible, in order that this advantage be maintained (House of Commons: Select Committee on Science and Technology 2001, para.56-58. These technologies are thus useful subjects for the application of any lessons learned from the historical development of the wind turbine industry.

Due to both the factors outlined in the Select Committee report, and the arguments relating to the likely similarities between the industrial models for wave and tidal stream technologies as outlined above, it may be useful to focus on these two technologies for the potential for the application of the lessons learned from the wind turbine industry, as opposed to technologies such as PV, which seem likely to have different industrial models. Further to this point, the evidence from the wind industry, seems to suggest that it will be small and medium enterprises initially driving the



development of wave and tidal stream technology, this differing from the greater degree of involvement by large corporations that defines much of the work in photovoltaic technology.

#### 10.4 Creating New UK Renewable Energy Technology Industries

The central issue to be addressed in this final chapter is the question as to which policy might most ably encourage the growth of new RET manufacturing industries in the UK. To this end, some observations are more likely than others to be capable of application across different technologies. Differences in the industrial model for particular technologies will, unsurprisingly, mean that some lessons may be more applicable to specific technologies.

As also described in chapter nine, the principal conclusions of this research suggest that the central strands of policy to encourage greater renewable energy exploitation may usefully include measures which specifically advantage the industry of the nation which is funding any potential growth. The example of Denmark, and its successful establishment and subsequent domination of the wind turbine manufacturing industry suggests that this may not be necessary where a nation and its industry are the first to enter the marketplace. This is not to suggest though, that a policy to protect an industry from competitors of other nationalities might not be useful in either early or later stages, to either maximise returns on investment in R&D and market stimulation, or to defend the market share of domestic companies

As has been discussed in chapter four, being the pioneer in a new technology also offers a wider range of options for stimulating an initial market without entailing costs that other, later entrants might have to bear. Whilst such considerations are no longer relevant to actors endeavouring entry to the wind industry, they are likely to be

relevant to potential new entrants to other RET manufacturing industries and are thus relevant to this chapter. They will thus be summarised here.

Examples of policy options more relevant to early industrial entry include compelling actors such as utilities to source a specified amount of power from a new technology is a common methodology for initially stimulating a market for a technology, and to effectively subsidise the technology up to a minimum production volume. Being the first actor in a new technology means that all the costs that this causes to be borne by utilities and by consumers will stay within the nation providing the legislation, any employment generated is in the country of origin, and there will be no negative impact on the balance of trade. Later entrants who employ the same mechanism on an open basis risk having the first mover seize part of their home market, thus gaining a foothold in the later entrant country, and securing some of the economic and social gains outside of the country where the new capacity is being installed. The alternative to these losses, for those nations trying to stimulate industry as later entrants to the market, is to limit obligatory purchases only to goods produced domestically. This may prove to be difficult to achieve politically however, both with regard to pressures against introducing what would effectively be blatant protectionism, and domestically with regard to limiting the source, and thus cost of purchases of goods to fulfil what is already a legislative obligation. In most legislative contexts, such a limitation might also be illegal or unlawful, though whether it encountered legal challenges might depend on the level of agreement between the relevant electricity supply industry and government as to the desirability of increased renewable energy use. For example, it would be difficult to imagine German electricity suppliers failing to challenge such a limitation, whilst in Spain,

where there has been far greater enthusiasm for utilities to get involved with RET, such a limit might be more acceptable.

Becoming the first nation to successfully stimulate an industry for a new RET may also be important to the long term dominance of that industry, with regard to the options it offers for the range of tools for favouring domestic industry. If the example of Denmark with regard to wind energy can be regarded as being indicative, first mover advantage makes it easier for a government to defend a home market by offering a greater range of policy options for doing so.

The primary example from the Danish wind industry is the use of legislation relating to safety and production standards. By enforcing standards in Denmark specific to that market, it has been effectively possible to make it more difficult to enter the market and operate competitively, due to the enhanced costs that accumulate in the testing process to achieve the required standards for licensing in Denmark, and to meet the technical specifications set down for all turbine sales there.

Essentially, a position of dominance may give a greater opportunity to employ regulatory measures to protect national advantage which do not rely on financial measures. Non-fiscal regulation, generally directives aimed at achieving either health and safety or environmental goals, may apply more heavily to non-domestic actors whilst, at least in theory, applying to all parties. They are therefore difficult to challenge. Fiscally-based regulation as a protectionist mode, as it has been exemplified most specifically in chapters five and six, is more likely to be open to legal challenge, for reasons explained in chapter three.

The use of non-fiscal regulation for this purpose can also serve as an example of one of the potential benefits of good lines of communication between government and industry actors. By being aware of the technology and its specific use, and of the

needs of the industry, it may be possible for a government to respond to those needs with legislation and regulation which help to create advantage.

#### 10.5 Industrial Policy and its Effects on New RET Industries

It is important to note that the new RET's differ from wind in a number of ways, other than the technical. Besides the industrial models already touched upon, they are obviously less established in terms of market size, but also in the security of those markets that exist, if they exist at all, in the size of the industry, in the likely industrial phase of each respective industry and in other attributes such as the sophistication of consumers. These factors are all notable in the context of this research, though some are more significant than others. Essentially, each of these factors is a reflection of the fact other RET's are at a less advanced stage than wind energy technology, and at an earlier industrial phase. It is important that this is remembered, in applying any lessons from the wind energy industry.

Whilst it is suggested that it is essential to establish a domestic market in order to engender even the possibility of a domestic industry, it has repeatedly been pointed out that the creation of such a market may only create a market for industries in other countries. There is considerable evidence that the early application of protectionist policy may be wise to ensure that the maximum advantage is secured for the nation who is funding the creation of the market. Abundant examples of policies with the potential to be used for protectionist purposes, or of protectionist policy actually in practice with regard to the wind turbine manufacturing industry, have been detailed in the case studies highlighted here. These apply both with regard to the early stimulation of industry, and to the continued support of already established industry. Examples of policies to stimulate initial growth of a national industry have included the 250MW programme of subsidies from the German Research Ministry, BMFT,

which seems to have been directed largely to buy German products. The later application of ‘soft loans’ from organisations such as Deutsche AusgleichsBank and other state-backed investment banks for the purchase of turbines in Germany, may also have favoured German manufacturers. Though the evidence is perhaps less conclusive with regard to this soft loan provision, the effect was to support a market already balanced in favour of domestic suppliers. It is perhaps interesting to note that Uwe Cartensen’s approximation of German companies as receiving around two thirds of the support available under the 250 MW BMFT programme, is roughly equivalent to the fraction of the German market still served by German companies – though it should be noted that this is not proof in and of itself.

The early efforts of Spanish companies following the move to policies at both national and regional levels to encourage large-scale installation, were assisted by regional policies demanding local manufacturing, which it could be argued, they were better positioned to serve.

#### 10.6 Regulatory Protectionism and New Renewable Energy Technology Manufacturing

Policies to protect industrial interests such as these can be generalised as either fiscal or non-fiscal regulation as described in detail in chapter nine. There are ranges of possible policies to fall within either of these categories, not all of which have necessarily been employed in the wind turbine manufacturing industry up to the present, though many have the potential to be used should they come to be regarded as desirable, useful and politically acceptable.

The problems of protectionist policy in terms of free markets have been discussed in depth in chapter three. In basic terms, thinking on such policy recognises that they are barrier to the open operation of the market. However, where competitors

are prepared to employ policies which protect their domestic industries, it may be easiest to respond in kind, than to protest against the legality of the instruments they are using. Whilst the barriers to the use of what Vogel (Vogel 1997) terms 'regulatory subsidy' are growing, it places nations in the position of competing to outdo their competitors in the introduction of new regulations which grant advantage to their own industries. Various methods for this have been detailed in depth in chapter three, as well as having been exemplified in the case study chapters.

Policies from both the categories of financial and regulatory subsidy have the potential to be applied to a number of the new RET's which are presently being developed, or which are under consideration for exploitation within the UK, and which might be useful in either the short or long term for supporting the growth of new industries.

The provision of R&D funding to specific UK companies would seem to be a useful starting point for the seeding of new companies in nascent RET industries. Obviously, the provision of R&D funding has been continuous, though variable in magnitude, and as has been discussed in chapter three, is not even regarded as protectionist generally, but rather as an expected government support mechanism to encourage innovation and technology. As pointed out in chapter three, the indirect funding of R&D to support the development of specific technologies can be both direct and indirect. Indirect R&D to research institutions is likely to be free from contention, more direct methods of funding relevant companies may draw more attention. There is clearly room for interaction between both industrial and academic research in the area, and ideally this might be carried out with some input from government in order to maximise the usefulness of the R&D investment.

The issue of integrating the efforts of government and industry is an important one. The initial stimulation of the wind turbine industry in Denmark owed much to the close ties between these actors, as detailed by a number of commentators (Jamison, Eyerman et al. 1990; Karnøe 1990; Gipe 1995; Jørgensen and Karnoe 1995; Andersen 1997; Andersen 1998; Heymann 1998; Andersen 2000). Such integration is important for developing general policies aimed at growing the market, but is essential to ensuring that efforts are not at odds with the needs and the capabilities of industry. A primary example of such a failure in communication between government and industry is related in chapter seven. Essentially, the failure of the UK government to communicate properly with industry, and lack of awareness of its capabilities, meant that the early rounds of the NFFO were particularly unsuited to the needs, and to the limits of the UK wind turbine manufacturers. The details and likely causes of these problems can be effectively summed up to be the overloading of the capacity of UK manufacturing to produce anything more than a small fraction of the equipment needed to meet the demand created by the conditions inherent to the market created by the NFFO. To a large extent this can be regarded as a reflection of the Government's attitude to renewables as an aside to nuclear in the first rounds of the NFFO, and this in turn can be seen as betraying a lack of real commitment at that time, not only to the policy of helping to create an internationally competitive industry in the UK, but to the other commitments made as part of UK renewable energy policy at the time. In terms of industrial policy this move can only be regarded as a policy failure.

The present position of the UK government in accounting for the views of industry allows for a assortment of modes of communication. All recent policy documents concerning renewable energy in the UK have been produced as part of, or

as the direct result of, consultation with any bodies which regard themselves as having an interest in the field. Naturally, the various renewable energy industries and their representatives have all taken part in the various consultation exercises, and their inputs can be considered likely to at least some degree to have affected the present policy proposals regarding the introduction of a Renewables Obligation, though it may be that this impact has been relatively minimal, perhaps limited to operating details of the mechanism, rather than the choice of the mechanism itself.

As had been mentioned in chapter seven, the structure of the RO is likely to mitigate against an increased market for technologies which are presently less economic. Increased support however, might allow these to become more competitive in the future, and this might also bring both new markets, and significant levels of industry to exploit them. Policies introduced alongside the RO, such as grants to offshore wind and energy crops, and the establishment of the Orkney wave energy test station, may go some way to providing a foundation for a market for new technologies, though clearly these are unlikely to attract the same level of investment that the market ready technologies will be enjoying within the RO.

The role and uses of R&D support has already been mentioned here. The introduction of the RO came alongside a reaffirmation of the commitment to increasing the R&D budget to £14 million for the year 2000-2001, though this is still significantly less than other major economies have committed to their own RET R&D efforts.

The UK government has also already committed to making a 150% tax credit available to SME's spending more than £50,000 per annum on RET R&D as part of the Finance Act (2000). This, incidentally, being the same piece of legislation which granted renewable energy an exemption from the Climate Change Levy. The tax



credit is effectively equivalent to a 30% reduction in R&D costs (DTI 2000c; HMSO 2000).

It should be noted that provision of R&D funding differs from the majority of instruments that can be easily used to stimulate renewable energy markets and industries, in that it is not a regulatory measure, a term which, as Jacobs points out, encompasses practically all of those measures that can be regarded as comprising environmental policy (Jacobs 1998).

The case studies in chapters four to seven detail a number of regulatory options which have the potential to stimulate and support national industrial growth, whilst also achieving the intention for which they were ostensibly introduced. At least some of these are likely to be applicable to the stimulation and protection of other RET's in a range of countries, and specifically in the UK.

Following the development of new technology, the most important factor in stimulating a new industry towards growth is finding a market. Government can aid this process by specifically creating a market, and it is in the interests of such a government to have its domestic companies take the greatest possible advantage of a market so created. Perhaps the most simple mechanism for doing this is by offering grants to project developers to use the technology, making otherwise uneconomic undertakings profitable. One example of the success of such a scheme was the early German support mechanism which stimulated 250 MW of sales through direct subsidy, the bulk coming from German suppliers as mentioned above. Directly mimicking this method in the support of UK industry would be likely to prove more difficult in the UK than in Germany, for all the reasons that have been discussed previously in chapters seven and nine.

The supply of grants for up to eighteen large offshore wind projects as announced by the UK Government in 2001 offers the chance to attempt a similar application of policy in the UK. The UK Government seems to perceive offshore wind as being a different enough technology application from the onshore use that it might offer the chance for UK companies to gain access to markets, if not for the turbines themselves, then for the technology required to support and connect them. This discrimination between offshore and onshore wind would appear to be the major factor which differentiates the application of the technology when comparing the two applications.

The use of grants for offshore wind clearly indicates that they remain at least a possibility for use in stimulating further new technologies, though the strict limitations on the level of aid available would still seem to indicate that they are unlikely to be utilised on a scale comparable to programmes seen in other European countries. Considering the UK Government position that tidal stream has the potential to be producing significant power in the UK before 2010, alongside the expressed UK policy aim that RE industries are desirable, it would seem to be consistent to consider making available grants to stimulate the market use of the technology as soon as it becomes technically useful, in order to maximise any advantage that might be captured. The use of such grants becomes considerably easier to direct towards domestic industry if said industry is already dominating the domestic market. Thus their use in regard to technologies where the UK can still achieve a dominant industrial position makes more economic sense than for industries where the UK will be fighting against established interests to institute a presence.

The other major strand of the policies announced in the Renewables Obligation Preliminary Consultation (ROPC) was the 'Development of a proactive

strategic approach to planning in the regions and the introduction of regional targets for renewables based on renewable energy resource assessments' (DTI 2000b, pp111). This is not a straightforward example of a policy with the potential for application to stimulation and protection of domestic industry. Rather it is a policy designed to remove institutional barriers to the expanded use of the technology. It may however be of some interest in these terms if the scope of the use of regional efforts is expanded such that it mimics the efforts of Spanish regional policy in enforcing the manufacture and supply of RET from local suppliers. This though is probably more pertinent for wind energy than for other technologies for the foreseeable future, and is anyway of questionable legality with regard to the regulations concerning the free movement of goods in Europe.

Outside of those policies to which the Government has already committed, there are a range of options that might make creating and dominating a market for a new RET easier, and which could be made available in the UK. In one form or another, these will belong in the category of regulatory measures as has already been described.

A further measure proposed by the Select Committee is the establishment of a 'National Offshore Wave and Tidal Test Centre' to facilitate the more rapid development of both of these technologies (House of Commons: Select Committee on Science and Technology 2001, para.55). The usefulness of Risø in the continued improvement of Danish wind energy technology, makes such a centre irrefutably a significant benefit in both establishing and attempting to maintain a lead in an RET industry. The importance is underlined by the statement also provided to the Select Committee by the two existing UK wave technology companies, that they would move their base of operations to Portugal if the UK Government did not set up such a

centre in the UK. Such a facility should be able to defer significant costs from manufacturing companies as it has with regard to wind in Denmark, largely by allowing different prototypes to be tried out. Risø also proved to be useful in applying the use of standards in order to improve the quality of Danish turbines. This had a positive effect both for the increased use of the technology in the early days, as well as impacting on the later expansion of Danish interests into the world-at-large. Latterly, Risø also acted as the central hub for the accreditation of blades as suitable to meet the performance measures laid down by legislation, thus acting as the practical centre for these measures, which as described above, acted to assist in Denmark continuing in its dominance of its national market. There is no reason that a UK Test Centre, be it for wave, tidal or other RET, could not perform a role similar to Risø's, as well as usefully assisting in meeting research needs and offering a number of other advantages.

The announcement in mid-2001 that a test centre for wave energy technology was to be established off Orkney, Scotland should act to support R&D for the technology and offer the opportunity for further applications of policy in the future, as detailed above.

Establishing separate centres, or expanding the range of the centre to assist other technologies, would serve as a base and as a focus for carrying out R&D in conjunction with industry, thus minimising the costs of such research to industry. Test centres can also act as a conduit for communication between industry and government, as well as with academia, as has been the case with the Risø station in Denmark. Such communication has been a vital and continuing part of Danish success in the wind turbine industry as noted in chapter four.

Such a station would be a strong support to any UK efforts to access the wind turbine industry, as well as aid in co-ordinating efforts with regard to newer RET's. By formalising communications between government and industry it would allow government to gain an increasing awareness of the needs of industry and to respond to these with appropriate support. These responses could include direct financing of specific areas of research with regard to policy more easily aimed at specific barriers to the use of renewable energy generally, and the adoption of RET supplied by UK manufacturers specifically. Further to this point, a UK test station would be able to act as a base for the physical implementation of regulation based on ensuring that RET equipment supplied for use in the UK complied with standards relating both to safe operation and to specified quality benchmarks. The improved communication that a station would assist between industry and government should allow such regulations to be styled so that they particularly suit the needs of the UK industry. Such regulation would also afford the potential opportunity to create circumstances wherein non-domestic industries would be forced to make alterations to their technology in order to service the UK market. The reduction in their comparative competitiveness would thus provide at least a partial safeguard to any domestic operators in their home market.

#### 10.7 Government Procurement

It was suggested in the previous chapter that government procurement of RET is likely to be an inappropriate mechanism for market or industry stimulation with regard to wind energy in the UK. Such limits, created by political commitment to the opening of markets and minimising costs to the consumer, are likely to also apply to most other RET's under consideration here. The normal course of government procurement procedures would see the government tender for the supply of energy

rather than for the equipment itself. This direct purchasing of electricity from suppliers helps to stimulate markets but is less controllable in terms of giving competitive advantage to domestic industry. One notable exception to this may be the potential for the use of photovoltaic technology in public buildings. In addition to electrical generation, PV cells provide an alternative façade material, thus providing value beyond the basic supply of energy, and enabling direct purchases of the technology to be made more easily. Purchasing of this nature is likely to be more easily used as a tool to support purchasing from domestic sources, as well as acting to increase the size of the market. In sufficient quantity, such purchasing might help to attract manufacturing capacity and to stimulate new entrants to the market.

#### 10.8 Applicability of Policy Across Borders and Industries

I have suggested here that many of the factors which aided the successful growth of the Danish wind industry may be mimicked for other RET industry through direct use of similar policy, or by effectively imitating the effects through policies which better fit the national innovation system of a particular nation. Whilst this may be the case, many important characteristics, especially social factors, may not be easy to replicate. These factors are particularly notable for their importance during the early stages of the wind industry in Denmark. The typological theory proposed by Low and Abrahamson supports this, both in general terms and with regard to the evidence in the Danish case study, as has been demonstrated here. To further clarify this however, it should be noted that it would be unwise to suggest that it would be impossible for an RET industry to develop without mimicking the social factors that were present in the Danish case, though it is not possible to easily speculate as to what alternative paths might be available. Clearly there is the possibility for a variety of

routes to successful industrial development, as there are alternative routes to the use of regulation.

One interesting aspect of the development of new industries, and of those who attempt to access them are the comparative roles of small- and medium-sized enterprises (SME's) in comparison with larger, generally multinational, companies (MNC's). As has been described, success in the early establishment of the wind turbine manufacturing industry has largely been the province of SME's. Historically, those large companies which attempted to access it, often with the encouragement of government have proved less successful. As the industry matures however, there is evidence that this might be changing. The new companies which have enjoyed success in the Spanish market are on a larger scale, and the strength of the market internationally is also drawing the increased interest of major MNC's, such as ABB. (ABB 2000). The need for new entrants to a mature industry to be able to access significant resources in order to acquire the knowledge to compete technologically, and to construct a company with a vertically integrated structure in order to maximise low margins has been discussed in chapter eight. One interesting question is how important are the respective roles of SME's and MNC's in driving the development and use of new renewable energy technologies. The companies operating in the relatively new fields of tidal and wave energy seem to be largely SME's. The companies active in PV manufacture however, include major MNC's such as Shell and BP, and a number of major Japanese actors. The role of MNC's in PV manufacture is clearly defined to a large extent by the need for extensive R&D expenditure inherent to what is effectively a more complex technology. With regard to the wind turbine manufacturing industry, this would seem to be connected with the roles of 'learning through doing', as employed by the SME's, as opposed to the role

of 'learning through research' utilised by the MNC's initially involved in the sector. This was discussed in the early chapters. In turn, it can be suggested that this 'learning through doing' approach was a reflection of the involvement and actions of the grass roots actors active in the early stages of the Danish industry. With the possible exception of PV for the reasons outlined above, it will be interesting to see which actors enjoy the most success in both the early and later stages of the new RET industries, and the role that socially motivated rather than economically motivated actors take in the early development of the industry and when, and if, they are replaced by more purely economically oriented actors.

The degree of involvement of MNC's in RET's, and their level of actual impact has been mixed. MNC's have not been keen to re-involve themselves with wind energy technology since initial failures with the technology, and whilst it was still perceived as a potentially risky investment. This was confirmed by at least one interview subject representing an MNC involved in RET, who commented that the MNC's preferred to leave investment till later when risks were lower, acknowledging that this might also mean lower profits. Naturally, MNC's will have the advantage of being able to then utilise their superior financial strength to ease their access to an industrial sector once it has been decided that such a course might be profitable. Andersen and Jensen (Andersen and Jensen 1997) suggest however, that the wind turbine industry, in becoming effectively globalised at an early stage in order to meet the demands of a rapidly expanding marketplace, have already begun to display signs of a shift from SME's to multi-nationals. This is in agreement with the behaviour predicted by this research in the application of Low and Abrahamson's typological theory, as discussed in chapter eight.



The issue of imitating social factors leads to the issue of the role for policies offering competitive advantage in the context of the industrial phase in which they might be initiated. For example, would the greater likelihood of involvement of socially motivated actors, at the emergent phase and to a lesser extent at the mature industrial phase, both as consumers and manufacturers, make these more favourable phases for the use of policy instruments which have implications for the location specific emplacement of manufacturing centres. By extrapolation, what implications for the location of many of the social benefits prompted by the new industry would this have. This can certainly not be dismissed, though any specific conclusion would have to depend on further research around the issue.

#### Main Points of Chapter Ten

- The fundamental basis for securing viable international renewable energy technology (RET) industry lies in ensuring a strong domestic base.
- The UK may be better placed to take advantage of new RET manufacturing opportunities than any remaining opportunities in the wind turbine manufacturing industry.
- Both the wave and tidal stream may offer significant business opportunities, whilst offering less competition than the wind industry.
- The opportunity for first mover advantage so fundamental to the Danish wind turbine manufacturing industry is still available for the wave and tidal stream industries.
- There are a number of valuable lessons regarding the protection and stimulation of new RET industries to be learned from the examples of Denmark, Germany and Spain in wind turbine manufacturing stimulation.

## **Chapter Eleven: Summary of Thesis Conclusions and Areas for Further Research**

### **11.1 Conclusions**

This short chapter will précis the three concluding chapters to provide a synopsis of the conclusions of this research.

As noted in outlining the original hypothesis in section 1.2, there were a number of intended purposes behind this research. The first was to assess the possibilities for any remaining opportunity for the UK to access to the wind energy manufacturing industry, and to then suggest any lessons that might be learned from both previous UK policies and from the policies of other countries that have perhaps enjoyed more success in the field. A further aim was to then assess whether lessons learned from the development of the global wind turbine industry might provide lessons for the growth of other renewable energy technologies. One codicil which should be borne in mind is that whilst this research contemplates the possibilities for the application of policies between countries and technologies, it is important to note that there may be alternative routes to success which have not been considered here.

Essential to assessing the usefulness of the UK enacting policies to attempt to enter the wind turbine manufacturing industry, and in what role, is the issue of whether there remains an opportunity to do so. The case study of Spain, and of the Spanish use of wind energy in chapter seven provides a simple argument that it is still possible for a country to grow a new manufacturing industry for wind turbines. A more complex justification for the possibility of opportunity remaining open is then presented in chapter eight. This chapter demonstrates the close fit between the industrial growth of the wind turbine manufacturing sector and the generalised model for industrial development within the context of a typological theory produced by

Low and Abrahamson (Low and Abrahamson 1997). It demonstrates that in addition to the simple perspective offered by the Spanish example, there is likely to be a further opportunity to access the market due to an impending change in the industrial phase of the sector. This change is likely to destabilise the current industry to some extent and offer greater opportunity for new entrants to the market to gain competitive advantage over those companies presently dominating the marketplace. Additionally, the chapter demonstrates the accuracy of Low and Abrahamson's typological theory as a descriptor for general industrial development.

Chapter eight also gives some consideration to the likely characteristics of companies capable of surviving in an increasingly mature industrial sector. It suggests that larger companies are likely to have the advantage as new entrants, as only they are likely to be capable of generating the investment capital needed to capture large portions of the value chain in order to minimise margins sufficiently to become competitive. Interestingly, the head of the European Wind Energy Association went on record in 2001 as suggesting not that the wind industry needed more companies, but that it needed larger companies to be able to afford the scale of investment necessary to support the continued rapid expansion of the industry, and to enable it to diversify both in product and geographical range (Aubrey 2001).

Chapter nine addresses the usefulness of policies employed successfully in encouraging wind energy usage, and more pointedly, in encouraging the growth of a domestic industry to serve the market thus created. In particular it notes the Spanish device of requiring the use of locally manufactured wind turbines by companies wishing to develop wind farms, as well as the usefulness of devices such as the Risø tests station and the German system of soft loans. The chapter discusses the applicability of the use of such policies in the UK to achieve the ends achieved

elsewhere, in the context of the particular NIS of the UK, and comments on the appropriateness of each measure in this context. Particular emphasis is given to policies which help to create competitive advantage for companies operating in their domestic market.

Fundamentally, as an interpretation of the information gathered in the case studies detailed in chapters four to six, it is suggested that no country which has so far been successful in assisting the creation of a wind turbine manufacturing industry has done so without having in place some mechanism which has helped to create competitive advantage for its domestic companies. To clarify, the essential conclusion to be drawn is that, in order to access the wind turbine manufacturing sector, the UK needs to introduce policy which creates competitive advantage for UK companies.

Chapter nine suggests that some of the early policies enacted in the case study countries of Denmark, Germany and Spain would be inappropriate for use in the UK for a number of largely political or social reasons. However, it also points out that some of the policies enacted in the support of wind energy in these countries may be useful to achieve the same end in the UK, either by their introduction on an almost direct basis, or at least as a general indicator of what might be a worthwhile policy to pursue.

Chapter nine builds on the conclusion of chapter eight – that it is still possible for the UK to establish a competitive wind turbine manufacturing industry – by discussing some of the possibilities for assisting such establishment. It emphasises the importance that policies with protectionist potential have played in maintaining domestic markets and ensuring domestic wind turbine industry has thrived in them.

Chapter ten takes the lessons that might be learned from the industrial development of wind energy, primarily from its progress in Denmark, Germany and Spain, but where appropriate from other sources. It assesses the potential effectiveness of policies enabled in these and other locations, as well as some other potential policies that might allow the same or improved results. Commentary again is related to the policies through which the UK might be able to gain competitive advantage for its companies, and again addresses the problems of adopting regulation for this purpose in a country with a strong political commitment to deregulation.

Both chapters nine and ten also address the difficulties of adopting regulatory measures in the UK, the nation that the OECD presently rates as the least regulated in the developed world (OECD 2000). Both chapters attempt to assess what difficulties particular policies might encounter and which policies might meet less barriers. Finally, a number of suggestions are made as to what might be applicable policies for use in encouraging wind energy industries in the UK, both in general and specific terms.

It is suggested overall that fiscal forms of regulation relying on subsidy would be politically difficult to bring into place in the UK in support of industrial policy to encourage the expansion of a UK manufacturing presence in the wind turbine manufacturing sector, or generally for most other forms of renewable energy technology. The NFFO and its successor, the Renewables Obligation are regarded as acceptable forms of subsidy, on the grounds that they contain a competitive element which, it is reasoned should more rapidly reduce the price of the technology, and thus alleviate the eventual need for the subsidy to exist at all. This commitment to the belief that competition is the fastest mechanism for reducing prices, rather than a commitment purely to increasing capacity and gaining economies of scale, and that

this is also the way to ensure the minimum economic burden on consumers forms the basis for UK policy on renewable energy, and energy generally. Mechanisms which are not based on the this criteria are politically much less acceptable. It is thus further suggested that non-fiscal tools would be more appropriate to encouraging UK manufacturers and to helping them to achieve competitive advantage in any domestic market created in support of their establishment. Clearly, the introduction of grants to support offshore wind energy growth is an example of a further form of financial subsidy. However, the UK Government has repeatedly emphasised that the availability of these will be strictly limited, and thus the role that they play will also be limited. The strict limitations placed on this mechanism also serve to underline the attitude to the use of such direct subsidy.

More specifically, it is suggested that the establishment of a test station for renewable energy technologies should be a priority for a large number of reasons relating to the assistance of UK industry, with regard to the possibility of encouraging new entrants to the wind turbine industry. Such a facility could act to encourage the establishment of support industries for a central wind turbine industry, and to assist in creating a UK industry for new RET's other than wind. The range of benefits such a station would provide have been described in detail in chapters nine and ten, and include; a central focus for R&D; a focal point for communication between government, industry and academia; a centre for the establishment of standards for technology and for the introduction and regulation of safety protocols and licensing for the industry. The last item on this list is of particular importance in the context of this research as it provides a particular example of a policy which could be adopted in the UK which could specifically grant some degree of competitive advantage to UK manufacturers, or to any manufacturers which the UK Government wishes to favour,

and which can be introduced with a minimal amount of political opposition. The announcement in mid-2001 that a test station for wave energy will be constructed at Orkney, Scotland signals the UK Government's response to the Select Committee's recommendations, and displays that the government is aware of at least some of the useful benefits that such a centre could bring in aiding new industry (Scottish Executive 2001). It will be interesting to see if and how policy will develop to take advantage of the full range of possibilities for the use of such a station.

Chapter ten also emphasises the importance of long term commitment to policy on developing RET's and the corresponding industries, and notes that the UK's Renewable Obligation is planned to last for 25 years, a hopeful indicator for future policy thinking.

### 11.2 Further Research

The results of this research indicate a number of possible directions for future work. Some are specifically linked to the development of renewable energy technologies and to the stimulation of both renewable energy markets and industry, some more generally applicable to the development of environmental technologies and the industries relevant to these.

Most specifically linked to renewable energy technology, would be the application of the findings of this research to possible efforts to derive policy for stimulating both renewable markets and industry in countries other than the UK, and in technologies other than the ones broached here. Linked to this there are possibilities, now or in the relatively near future, of carrying out assessments of new renewable energy technologies (RET's) in terms of their historical industrial development, as carried out with regard to the wind turbine manufacturing industry by

Karnøe in 1990 (Karnøe 1990). Technologies which may be most relevant and which might make possible early candidates for such an assessment may include wave and tidal stream technology, dependent on how the technology develops in the near future. Technologies relating to bio-mass may also be apposite but it is beyond the knowledge of this researcher to make that judgement. Further consideration of the likely industrial models for different RET's may also prove to be fruitful.

Another topic likely to warrant examination, and related to renewable energy policy, but also general policy regarding industrial policy as it applies to encouraging environmental industries, is the future performance of the UK's Carbon Trust. As has been noted here the Carbon Trust has been brought into existence to encourage the efforts of UK industry in 'low carbon technologies'. As has been described in chapter seven, there are some parallels between the proposed operations of the Trust and the role of some investment banks in Germany. At the time of writing, the Carbon Trust remains in the process of taking on senior staff and thus has not yet begun to fulfil its duties. However, it will be interesting to see precisely how the functioning Trust will operate in terms of the way in which it directs funding, which actors receive funding and what policy constraints underlie the division. Most importantly, it will be interesting to see what results the Trust manages to engender in terms of both stimulating UK industry and with regard to reducing greenhouse gas emissions.

A further area of more general interest concerns the use of regulatory measures ostensibly aimed at protecting the environment, but which effectively create a competitive advantage for the industry of the nation which introduces them. Such regulation is becoming increasingly common as other options for protective regulation are ruled out under the expanding purview of the WTO, EU and other free trade



bodies. EU law specifically includes that differences in national laws may legitimately create situations wherein domestic legislation may favour domestic actors where this is the best way to achieve an environmental or health related goal which can not be more easily achieved through other policy and where the creation of competitive advantage is not the *raison d'être* of the legislation (Geradin 1997). Whilst there is considerable literature in this area, one aspect of the increased use of such regulation that does not appear to have been investigated is the potential for its use by environmental NGO's as an additional benefit of those policy options they champion as potentially bringing environmental benefits. There are essentially two aspects to how this might affect the strategy of NGO advocacy of environmental policies. The first is that it is an additional factor which might inform the decision making process in determining which policy can best achieve the intended aims of the NGO, whilst also having the most appeal to other actors, and thus have the most chance of being enacted. The second aspect is in fostering a greater understanding of the policy creation process.

A further topic, which might also warrant investigation, is the use of the term win-win, and its corollaries, as they apply to solutions to environmental problems. Presently the term is used to describe solutions to environmental problems which result in favourable outcomes for both the environment and for business. The term is applied both at the micro- and macro-economic levels. It is suggested that the term can be quite fairly applied at the micro-economic level as this can generally be understood to involve two sides in a negotiation, a particular business actor and the representative of the environmental cause, be it government, a regulator or NGO. At the macro-economic level however, where the term is also applied, it is suggested that the term is less appropriate as there are likely to be more than two positions to

consider, and that the situation is less clear-cut. It is suggested that there is a case to consider a multi-dimensional model, capable of mathematically taking into account the variations due to the wide variety of factors that need to be accounted for. More simply, it is suggested that in practical terms, the use of only two terms, for example win-win, win-lose or lose-lose, when describing the effects of policy fails to take into account the possibilities for future economic gains to be derived from markets stimulated by the introduction of environmental legislation. In current use, the term is useful only to describe the effects on current industry and on the environment. It is suggested that a three-factor taxonomy might more ably describe the possibilities for describing the actual merits and demerits of the economic-environment interface, and might help to emphasise the possible economic benefits of new environmental regulation.

The use of a three factor taxonomy, as opposed to the two factor taxonomy which is largely employed, is relevant to the development of new renewable energy technologies on the basis that many of the benefits of RET's, and specifically their industrialisation, are in the position of being future economic gains. As explained above, these may not be as apparent as the economic losses which are taken into account in appraising the costs and benefits of any environmental policy. Essentially, it is suggested that taking into account the future social and economic paybacks of both public and private investment in new environmental technologies needed to achieve positive environmental goals may enable these benefits to be more apparent and thus new policy to be more acceptable. The effect of this may be to more easily allow new environmental technologies to receive public support, both through fiscal and non-fiscal regulation. Such an effect is key to the discussion of industrial development which is central to this research.

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## Appendix A

### Average Electricity Prices for the Case Study Subjects – 1999

#### Domestic

Country	Price (US\$/kWh)	Local Currency
Denmark	0.207	1.49DKK/kWh
Germany	0.152	0.288DM/kWh
Spain	0.143	23.1pta/kWh
United Kingdom	0.117	7.42p/kWh

(IEA 2001)

#### Industrial

Country	Price (US\$/kWh)	Local Currency
Denmark	0.066	0.476DKK/kWh
Germany	0.057	10.8pfg/kWh
Spain	0.056	9.04pta/kWh
United Kingdom	0.064	4.06p/kWh

(IEA 2001)

## **Appendix B**

### **Typical Financing Rates for Wind Turbine Projects**

It should be noted that precise information regarding financing rates for wind turbine projects is of a commercially sensitive nature, and thus it is only possible to give approximate figures. It should also be borne in mind that rates will vary dependent on the nature of any contract relating to a specific project.

Rates will be higher for funds borrowed from the private sector than the public sector, though it should be noted that public funding is not available in all countries.

Denmark: 5-6% over 20 years (Krohn 1999), 7% over 20 years (European Commission 1999)

Germany: Rates are variable, starting from 5% but with a likely typical rate of around 6.5%, calculated over 10 years, with up to 100% of costs available (European Commission 1999).

Spain: No figures are publicly available.

UK: Triodos Bank, which finances wind projects through its Wind Fund suggest a figure of 2-2.5% above base rate over 10 years, with funds available up to 80% of costs (Triodos 2001). The European Wind Energy Association, in a document prepared for the European Commission suggest the rate for NFFO-3, 4 & 5 projects was variable, though unlikely to be below 7.5%, with a repayment period of 15 years (European Commission 1999). All NFFO projects are privately funded.

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